A Semimonthly Technical Newspaper

Metallurgical & Chemical Engineering

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Firm	Stokers Operated	What They Say
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National Enameling & Stamping Co. Granite City, Ill.	76	"No reason to regret our final choice in selecting the American Stoker."
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Allegheny Steel Co. Pittsburgh, Pa.	34	"Are getting highest possible efficiency out of fuel consumed."
Inland Steel Co. Indian Harbor, Ind.	33	"Stokers are working very satisfactorily."
The Canton Sheet Steel Co. Canton, Ohio	31	"Has given us the lowest cost we have had."
Wheeling Steel & Iron Co. Wheeling, W. Va.	68	"We can unhesitatingly recommend your stoker."
Commonwealth Steel Co. St. Louis, Mo.	17	"No words could express a better recommendation than the fact that we have just ordered six additional stokers."
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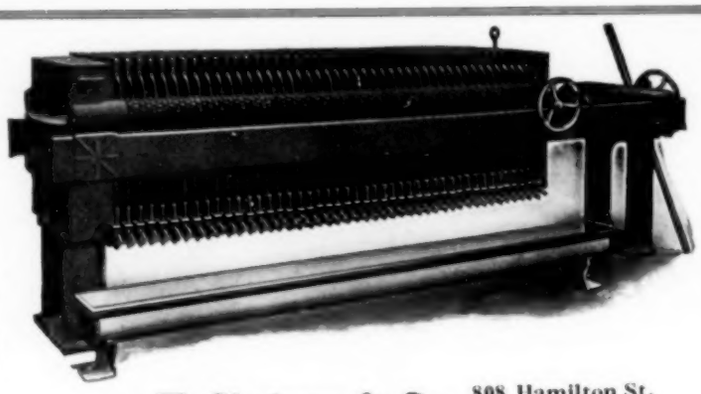

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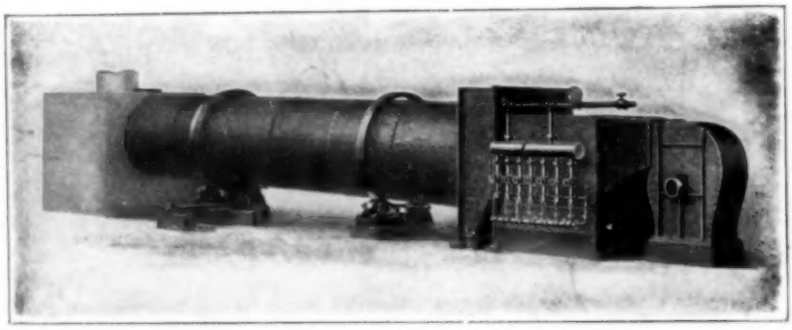

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Metallurgical and Chemical Engineering

A Consolidation of
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The Railroad Congestion

The railroads are found to be quite incapable of handling all the freight offered them, and the steel industry suffers more than other industries. Shipments are greatly interfered with as to both volume and celerity, and production is measurably reduced. It is natural that the steel industry should suffer most, for there are no really large industries that involve the movement of so much material in proportion to the finished output. The number of ton-miles of freight involved in placing a ton of commercial steel at its point of ultimate use is enormous. About four-fifths of the iron ore is moved a great distance, fully two tons of ore to a ton of finished product, while most of the coke is moved a considerable distance, about ton for ton. Then there is coal and limestone, which does not appear in the finished product, besides slag that must be carried away. Between works there is considerable movement of pig iron and scrap, as well as of partly finished material. Thus the railroads are called upon to do a great deal of work, and the least insufficiency in performance is necessarily reflected in the operation of the industry.

The efficiency of the railroad depends upon much the same items as does the efficiency of a steel mill. The blooming mill, for instance, must be supplied with ample power. The engine must be capable of delivering enormous power at slow speeds for the first pass of the ingot, like a locomotive starting a train, and it must be capable of high speeds for the final pass, just like the locomotive when it has a clear track before it. If either engine is inadequate for either the slow or the fast service the total capacity of the unit is reduced. There must be storage facilities for ingots and blooms, just as the railroad must have storage room at its terminals, and there must be a sufficient number of passes in the blooming mill as there must be a sufficient number of tracks on the railroad.

There is another line of analogy between the rolling mill and the railroad. Given certain specifications the rolling mill can produce a very large tonnage, and the customers who have filed those specifications are well satisfied. Other customers, the filling of whose specifications requires roll changes, sometimes have occasion to wait. It is related of a relatively small western road that while some of the shippers depending upon it are greatly incommoded the road is carrying the record tonnage of its history. At one junction point it is embargoed except as to train loads. The connecting line will accept train loads and nothing else, and it chances that this road is able to make up many such train loads, hence its large tonnage while many customers are suffering.

The experience of the steel mills in the past two or three weeks has shown conclusively that the weak element in the railroad equipment is the motive power. For a time car shortage was blamed, the mills not receiving sufficient empty cars. That could have been due to a variety of causes, but of late the supplies of cars at mills have increased but the facility of movement has decreased. When the cars are loaded the railroads are unable to carry all of them away, and insufficiency of motive power is now clearly indicated. It is particularly unfortunate that the difficulty should be at this point, for the reason that under the severe duties imposed the efficiency of the motive power decreases week by week, locomotives requiring repairs for which their time cannot be spared. Terminals and sidings do not wear out, nor do cars in any short period of time. Thus there is little prospect of material relief in the railroad situation in the near future.

No considerable number of new locomotives is to be delivered to the railroads in the near future. Statistics recently gathered by the *Railway Age Gazette* indicate this. It may be assumed that the locomotive shops had scarcely any orders on their books Jan. 1, 1915. In the two years since that date the domestic and export locomotives booked by shops in the United States and Canada totaled 7397, while the locomotives produced totaled 6160, leaving 1237 on books at the beginning of this year, and probably more than half of these were for export. As there are in service in the United States about 65,000 locomotives there should be thousands added rather than hundreds.

The Rat Problem

Somebody guesses that a rat census of the United States would show as large a number as that of the population; that it would be above the hundred million mark. Like flies and mosquitoes, they have not a single valuable quality and they not only carry disease but they consume vast quantities of human food. They are bearers of the contagion of bubonic plague and leprosy and they are the enemies of mankind. Indiana and Michigan offer pecuniary inducements to their citizens to kill rats. On Feb. 12 there is to be held a dead rat fair in Boston with prizes offered at the several "sanitary yards" of the city to citizens who excel in the de-ratting, the un-ratting, or entratting art; even the word has not been coined yet. The prizes are to be given by the Women's Municipal League and Mayor Curley gives encouragement to the effort.

All this is good, but it is likely to be sporadic in Boston and local in Indiana and Michigan. The great nation of rats, engaged in seeking life, liberty and the pursuit of happiness need not despair of the wrath of Boston or the legislation of the Middle West, provided they understand human nature, and with this they seem to be tolerably familiar. They are not so closely attached to their homes as are their feline enemies and on slight provocation they move. They travel easily by night, they have no loads of furniture to carry with them, and the proprieties of sanitation do not interest them at all, save as things to be avoided. We do not think the death-knell of the species has sounded yet.

Now let us see if we may not find a profitable use for dead rats, in which the problem of immediate transportation is not involved. If we make of ratkilling a profitable sport in which everyone so inclined may engage at his leisure, the death-curve among the species may grow sharper than the curve of increase. Of course, it takes a chemist to solve the riddle; in this instance a leather chemist. The solution is, tan their hides. Animals with thick fur have poor hides, those with thin fur produce durable, strong leather. The rat has thin fur. They are large enough for gloves, mitts, soles, inlays, buttons and a vast number of other uses to which leather is put. The skins are worth 10 cents each, easily. They may be salted down and nailed up against a barn door and dried. They will keep indefinitely. When a farmer has a couple of dozen set aside they may be carried to town in a basket and disposed of to the postmaster for $2.40. Five thousand skins a day would keep a tannery running profitably. The government would increase its parcel post receipts and do a grand service in that thing for which we lament we haven't the word yet—entratting, let's call it. It would be an act of altruism to buy and wear or use articles made of ratskin, which we offer as the cheapest and easiest method of achieving virtue that has been offered in a long time. If ratskins grew scarce and the tannery could operate only on part time, the price would go up and they would become fashionable. The tariff commission would then have an interesting problem to solve whether foreign ratskins should be admitted free of duty or not. When the problem reached Congress it would serve the excellent purpose of breaking down party lines—a consummation always devoutly to be wished for.

As for the cat and rat farm wretch who would raise these animals in captivity, selling the skins and feeding the carcases of cats to rats and rats to cats, it should not only be discouraged but legally prohibited; strengthily undersaid. Rat catching must remain a sport.

Changes in Steel Demand

It will be recalled that 1906, one of the best years the steel trade has passed through, with respect to there being a sustained and heavy demand, was a year of much new construction. The railroads were all active in laying new track and in adding to their rolling stock. There was much new construction in bridges and buildings. Conditions since the war started have been altogether different. New construction has been light, except where stimulated by the existence of war orders, while there have been large exports of steel. There are as yet no statistics of steel production last year, but it is of interest to compare the distribution of steel production, as to the various finished com-

modities in 1906 and 1915, as shown by the following table:

Percentages of Iron and Steel Production

	1906	1915
Rails	20.4	9.0
Shapes	10.8	9.9
Plates	12.9	12.4
Sheets	5.5	8.0
Tin plate	2.9	4.5
Wire rods	9.5	12.6
Bars	20.2	16.9
Skelp	7.8	9.4
Hoops	.9	1.2
Bands and cotton ties	2.1	1.8
Export billets, etc.	1.0	2.3
Miscellaneous	6.0	12.0
	100.0	100.0

The production of rolled material increased from 19,588,468 gross tons in 1906 to 24 392,924 tons in 1915, or by 25 per cent. As the proportion of rails was decreased by more than one-half, the actual tonnage decreased. Railroad buying in general decreased in somewhat the same manner. Another large decrease was that in bars, while structural shapes showed a small decrease. There was a slight decrease in the proportion of plates, and as shipbuilding was particularly active in 1915 it may be assumed that the use of plates in structural work underwent a proportionate decrease, as was the case with shapes.

The increase in the proportion of sheets, tin plates and hoops is not to be ascribed to the war but is rather a part of a continual expansion in the use of these light products, which are constantly being employed in new uses. All studies of steel production statistics indicate that year by year steel is entering more into the common everyday use of the people at large. There was a time, in the decade of the eighteen-eighties, when the railroads were credited with consuming fully half the iron and steel produced in the country. As the theoretical per capita consumption increases it becomes more and more a real per capita consumption and not merely an average.

The Engineer in Americanization

Last week Mr. and Mrs. Vincent Astor and the Immigration Committee of the Chamber of Commerce of the United States gave a dinner at the Astor home "to the engineers of America," the subject of after-dinner discussion being the part of the engineer in industrial Americanization. There is no more important subject for engineers to discuss at present, but the many digressions of a few of the speakers on that occasion clearly showed that the recognition of the real meaning of "industrial Americanization" is not yet universal even among prominent engineers.

The future of the industries of this country depends to a large extent on the immigrant. No detailed statistics is needed here to show that while the invention and installation of labor-saving machinery has made rapid progress, the need for more and more men has nevertheless simultaneously progressed at an increasing rate. Nor is the number all that is needed. We have emphasized before in these columns that the thousands and thousands of immigrants now working in contractors' gangs and unable to speak English represent an immense untouched industrial asset. Every one of them has a history and many of them have a trade and are masters at their trade, but so far we have been unable to make right use of them.

The industries owe to the immigrant laborer more than a full dinner pail. What is his due in the widest sense may be summed up in the term "Americanization." Above all he must learn English, since personal contact is everything. But the conditions of work and the conditions of living also count. The slums must go. There is something radically wrong with industrial works that cause slums to come into being or to be maintained. But the first step—the step that counts and that is most difficult—is to teach the immigrant English. How can it be done?

What really wonderful work is possible along these lines has been shown in the past nine or ten years by the International Committee of Young Men's Christian Associations (Industrial Department) which has enlisted 4500 college men who are weekly reaching 100,000 working men and boys in volunteer service. These young college men from 250 colleges are teaching English to foreigners, instruction classes of American workingmen, etc. What this means to the immigrant is clear; it is his first chance to come into sympathetic contact with Americans.

But it is even more remarkable what this work means to the young college man. This work reacts on him. To sow love is to harvest love. It means that a thousand men are graduating from our American colleges each year after having secured in this way a vision of their service opportunities and responsibilities and some experience in handling men with intelligence and sympathy.

Thus the Americanization movement is bound to react on the Americans. If it was emphasized by one speaker at the Astor dinner that the first thing to do is to Americanize the Americans, the work with the immigrant is one means of changing Americans into better Americans, of creating a broader vision of the responsibilities of service to mankind. To quote another speaker it is well enough to urge universal military service, but should we not emphasize "service" rather than "military"? The Americanization movement needs the help of everyone. Americanization should not be left so much to the individual employer's paternalism, but should rather become a legitimate function of every great industrial organization. And because this is so it needs the help of the engineer with his scientific methods of organizing.

The famous Astor home at 840 Fifth Avenue has seen many a brilliant fashionable function of ultra-fashionable society, but it has never been filled more freely with the true American spirit than at these dinners tendered by its present masters in the furtherance of industrial Americanization.

Readers' Views and Comments

Determination of Phosphorus in High-Speed Steels

To the Editor of Metallurgical & Chemical Engineering

Sir: The following modification of the present methods for the determination of phosphorus in high-speed steels has been found by the writer to be accurate and rapid, excellent results being procured on government standards containing various amounts of tungsten and vanadium.

Dissolve two grams of the sample in 1-3 aqua regia, and when the solution is boiling quietly add a few crystals of potassium chlorate. Evaporate to about 20 c.c. Then remove from hot plate, add 40 c.c. of water, cool under tap and filter, washing twice with 1-1 HCl. Next evaporate the solution to the "basic ring." Again remove from the plate, wash down sides of beaker with about 25 c.c. of water, cool and filter. Transfer solution to Erlenmyer flask and after neutralizing with 10 c.c. of ammonia and adding 15 c.c. nitric acid, precipitate immediately with molybdate solution. If vanadium is present, reduce with 5 c.c. of 3 per cent sulphurous acid just before adding the molybdate. Allow solution to stand 45 minutes after thoroughly shaking. Then filter, and determine phosphorus by titration with standard acid and alkali solutions.

Edward C. Kraus.

Laboratory Atlas Steel Co.,
Dunkirk, N. Y.

A Story

Anent the Editorial on Niagara Power Crisis in "Metallurgical & Chemical Engineering," Dec. 1, 1916

To the Editor of Metallurgical & Chemical Engineering

Sir:—Once upon a time there was a farmer who had a dairy ranch. He was not what might be called a scientific farmer, rather one governed by the rule of thumb. By dint of hard-earned experience he had found that his stock of cows flourished if he gave them a mixed diet. They grew sleek under it and delivered rich milk.

Part of the mixed diet which he offered them he raised himself on his ranch, while the other part—a special brand—he bought from an importer.

After our farmer had spent all summer on his country place he decided when autumn came to enjoy the winter months elsewhere.

To be sure that his farm hand would continue the successful feeding of his cows and that the creatures might flourish and continue delivering the same quality of rich milk he prepared a carefully and specifically worded memoranda of instructions.

Feeling assured that all was well planned for the coming winter, he departed for the city to enjoy the products of his ranch, together with his contented customers there.

As time drifted along, there gradually was expressed to him one complaint after another by his customers over the quality of the milk that was delivered to them and finally the quantity also decreased to such an extent that a number of customers were left completely without the white beverage.

Dismayed and chagrined our farmer took an early train for his ranch.

On reprimanding his farm hand for the bad quality and decreased quantity of milk he had delivered, the farm hand took his employer to the written feeding instructions carefully nailed on the wall and from there to the barn and there showed that the imported feed had come to an end. The instructions on the wall did not specify any alternative in case one or the other of the feeds would run short.

The farm hand offered the written instructions and the lack of imported feed as excuses for the shortage of milk and for the inferior quality. He had never considered applying himself any remedy nor had he considered advising with his employer, since no such proviso was made on the written instructions.

The farm hand happened to be a stickler for the letter and received his just reward for being so unteutonic in his management. He was fired!

By naming the "ranch owner," "Congress;" the "customers," "the people;" the "cows," "electrochemical industries;" the "ranch," "Niagara Falls;" the "feed," "hydroelectric power;" and the "farm hand," "Baker," the story is pretty nearly true—all but for the "fired."

J. W. B.

San Francisco, Cal.

Legal Status of Flotation Processes

To the Editor of Metallurgical & Chemical Engineering

Sir:—The decision handed down by the United States Supreme Court in the case of Minerals Separation, Ltd., et al. versus James M. Hyde is of importance quite as much from the light it throws upon the unnecessary impediments to the normal growth of industry which arise from our present system of issuing and adjudicating patents as from any bearing it may have upon the development of ore-dressing practice.

The patent upon which the charge of infringement was based, and the validity of which was denied, by the defendant is U. S. Patent No. 835,120. It will readily be understood that after 800,000 improvements in apparatus or processes have been covered by patents in this country, further "improvements," as we ordinarily call inventions, as termed in patent law, are likely to be so restricted in scope as to require very close and exact definition.

The patent in suit has been claimed by its owners to be a broad basic patent covering practically all of the commercially profitable methods of concentrating ores by the flotation processes. The specification of the patent relates that "we have found that if the proportion of the oily substance be considerably reduced, say to a fraction of 1 per cent on the ore, granulation ceases to take place, and after vigorous agitation there is a tendency for a part of the oil-coated metalliferous matter to rise to the surface of the pulp in the form of a froth or scum." The claims all call for agitation as the means of forming a froth with the use of "a small quantity of oil," or with oil, or oleic acid in amounts less than 1 per cent of the weight of the ore treated. A study of the "file wrapper" correspondence between the Patent Office and the inventor's patent attorney shows that the inventors applied for a claim covering "the process of concentrating ores which consists in separating the mineral from gangue by coating the mineral with oil in water containing a fraction of 1 per cent of oil on the ore, and recovering the oil-coated mineral," and a claim wherein was described a process in which the pulp was to be subjected to the action of compressed air for a separation of part of its valuable constituents after being treated by the methods de-

scribed in the other claims. The Patent Office refused to grant the claim not specifying agitation as the means of producing the froth, and also refused to grant the compressed air claim as not coming within the patent, but constituting an alternative concentration method.

The most marked feature of the decision granted by the Supreme Court is that it differs with all other decisions which have been passed upon the validity or construction of this patent. The United States Patent Office is held to have erred in granting too broad a patent. By inference, the German Patent Office was wrong in refusing to grant this same patent, which it held to make no new disclosure or contribution to the art of ore dressing. The District Court of Montana is held to have been in error in holding valid those claims of the patent which are not restricted to the use of a fraction of 1 per cent of oil. The District Court of Delaware made the same error, and also in the Miami case held the patent to cover operations which do not include agitation as defined by the Supreme Court as used in this patent. The Circuit Court of Appeals for the Ninth Circuit is reversed in its decision that the patent is invalid as a whole.

The Supreme Court says in part in the decision delivered by Mr. Justice Clark: "While we thus find in favor of the validity of the patent, we cannot agree with the District Court in regarding it valid as to all of the claims in suit. As we have pointed out in this opinion, there were many investigators at work in this field to which the process in suit relates when the patentees came into it, and it was while engaged in study of prior processes that their discovery was made. While the evidence in the case makes it clear that they discovered the last step which converted experiment into solution, 'turned failure into success' (the Barbed Wire Patent, 143 U. S., 274), yet the investigations preceding were so informing that this final step was not a long one, and the patent must be confined to the results obtained by the use of oil within the proportions often described in the testimony and in the claims of the patent as 'critical proportions' amounting to a fraction of 1 per cent on the ore."

The Supreme Court clarifies the issues of the case by clearly defining the scope of the process in these words: "The process of the patent in suit, as described and practiced, consists of the use of an amount of oil which is 'critical,' and minute as compared with the amount used in prior processes, 'amounting to a fraction of 1 per cent on the ore,' and in so impregnating with air the mass of ore and water used, by agitation—'by beating the air into the mass'—as to cause to rise to the surface of the mass, or pulp, the froth, peculiarly coherent and persistent in character, which is composed of air bubbles with only a trace of oil in them, which carry in mechanical suspension a very high percentage of the metal and metalliferous particles of ore which were contained in the mass of crushed ore subject to treatment."

Agitation, as the term is used in the patent, is thus defined in the complainants' own language as being such rapid mechanical stirring "by beating the air into the mass" as to impregnate the mass of ore and water with air sufficient to cause a very high percentage of the valuable minerals to float as a froth. That is undoubtedly the sense in which the patentees used the term "agitate to produce a froth" in this and allied patents in which no other means is mentioned by which the air necessary to produce a froth is to be introduced into the pulp. This patent specifically disclaims the generation of a gas within the pulp by the use of sulphuric acid as coming within the scope of the patent, and as has been previously pointed out the Patent Office refused to grant the claims calling for no means of introducing the froth-producing gas, or making compressed air the means of producing a froth.

The pneumatic process of flotation concentration which has come into such extensive use, and is preferred to the agitation froth process by many operators, was broadly described in a patent taken out in Great Britain by Minerals Separation and Theodore J. Hoover in 1910. This patent broadly describes a process for concentrating ores by introducing a gas of any kind through a permeable medium into an oiled ore pulp for the purpose of causing the oiled mineral to float as a froth and overflow and thereby be separated from the gangue minerals. Several methods were described for accomplishing this result and a number of forms of apparatus were described. It is understood that when an inventor in this country who had independently discovered this same process applied to the United States Patent Office for a patent covering this method, he was denied a patent on the ground that the process had been disclosed in the British patent and was already open to free use in this country, as its original inventors had taken out no patent covering the process in the United States.

The claim has been made that the process just passed upon is a broad basic patent covering the production of a mineral-bearing froth as a means of separating the metalliferous contents of an ore from the gangue, and throughout the suit the witnesses for the complainant constantly described the result of this process as a froth while no other process was held to make a froth. It is interesting to note that in 1910, five years after the alleged discovery of the process of the patent in suit, Minerals Separation took out two patents for processes in which it was said that there were already a number of well-known processes for producing concentration by the means of froth, stating: "The processes employed to obtain these froths or scums may be any of the well-known flotation processes as described, for example, in" —then is given a list including the patent under discussion and two patents preceding it, one of which is the Froment process, which was relied upon by the defense as one of the most important anticipations of the patent in suit. The Froment process patent was taken out about three years before the alleged invention of the process of the patent just passed upon by the Supreme Court. It was testified by one of the alleged inventors of the agitation froth process that he had in his safe for over two years preceding the alleged invention of the agitation froth process a report by Alcide Froment describing how his process should be worked, and that this report had never been seen by anyone save himself and the other two alleged inventors of the agitation froth process. The Froment pneumatic process was patented in Great Britain but not in the United States.

The decision of the Supreme Court seems to have been granted upon the assumption that there is a "critical proportion of oil," and that this critical amount is "a fraction of 1 per cent of the weight of the ore treated. The term "critical proportion of oil" is evidently used to convey the impression that there is a proportion of oil which will result in the production of a froth while more than that amount will not. The further impression was created that this critical proportion is "a fraction of 1 per cent of the weight of the ore treated." If these assumptions are correct it is to be assumed that the earlier processes referred to in the 1910 patents as "well-known flotation processes which produce a froth" must have used this critical proportion.

The defense introduced into evidence a number of tests using more than 1 per cent of oil which made as thick and permanent a froth as is obtained with less than 1 per cent of oil and yielded as good concentrates

and as high recovery. These tests were all made in an apparatus which it was conceded by all concerned was the best to be used in determining what could be done on a commercial scale, but these tests were objected to by the complainants as being mere laboratory tests. Several of these tests were repeated in the court room. Judge Gilbert in rendering the opinion of the Circuit Court of Appeals referred to this phase of the case as follows:

> The contention is made, however, that if indeed the prior patents disclose froth processes, the scum which the appellees' process causes to rise to the surface of the water is so different from the froth or scum which arises under the prior art, that it is a new result, and is not anticipated by anything in the prior art. Say counsel for the appellees: "You produce a froth which is not our froth," and again they say that the appellees' froth is "a pure metal froth," while that of the other patents is an "oil froth," and that the appellees' froth consists of air bubbles surrounded by metal armor without any appreciable quantity of oil connected therewith. The evidence in the case, together with the illustration thereof afforded by demonstration of the various processes which were made in the aid of the argument before this court, convince us that the froth in all these processes is the same, with the exception that there is less oil (as there must necessarily be) in the appellees' froth than in the others. The froths are all similar in appearance, they all rise to the surface after the same amount of agitation, they all gather with equal efficiency the same quantity of metal, and all may be removed from the surface in the same way. It is not literally true, of course, that there is no oil in the froth which the appellees produce. If there were no oil in it, there would be no froth. The quantity of oil that has been put into the mixture must necessarily be found in the froth. It would manifestly be a physical impossibility to create a froth consisting only of bubbles of air and the particles of mineral.

The decision of the Appellate Court was:

> We hold that to sustain the appellees' patent would be to give to the owners thereof a monopoly of that which others had discovered. What they claim to be the new and useful feature of their invention, as stated by their counsel, is "agitating the mixture to cause the oily coated mineral to form a froth." As we have seen, that feature was clearly anticipated by the prior art, and when the elements of the appellees' claims are read one by one, it will be found that each step in their process is fully described in more than one of the patents of the prior art, with the single exception of the reduced quantity of oil which they use. The patentees of the appellees' patent made a valuable contribution to the art in discovering the smallest quantity of oil which would produce the desired result. In doing so, they pursued the course which all skillful metallurgists would be expected to pursue. They made a series of experiments to determine how small a quantity of oil could be used successfully. They found, as all must find who apply the oil flotation process, that certain oils are adapted to use with certain ores, and that a larger quantity of oil is necessary for one kind of an ore than for another. The appellees admit that for some ores they use four times as much oil as for others. Their discovery that a small fraction of 1 per cent of oil is sufficient to produce flotation of the metalliferous matter cannot, as we have seen, be made by itself or in combination the subject of a patent. The appellees cannot take from others the right to use oil economically.

We are reliably informed that so soon as they learned of the decision of the Supreme Court, the staff of one of the largest mills which is using the agitation froth process raised the amount of oil used to more than 1 per cent and that they still get the froth result with as good concentrates and slightly better recovery. It is found necessary to use less of other reagents, and the grade of oil now used is so cheap that the net profits are practically what they were before. Other companies are adopting the same practice.

Apparently the decision of the Supreme Court was based upon a false assumption as to the facts involved, and the net result of litigation extending over five years' time and costing a fortune is, that after having proceeded within their free rights for two years and a half the companies using the agitation froth process are to be compelled to do what the court previously told them they could not be compelled to do; that is, to use more oil than is necessary to accomplish the result desired.

If, as is demonstrated by this case, the courts cannot be expected to agree with each other with regard to the interpretation of the law and the bearing of facts, it should be apparent that the least possible interference with the progress of industry would come from having all patent cases heard by a single court constituted of judges selected for their technical training and experience and knowledge of the law, this court being a part of the Patent Office and having sole and final jurisdiction in all patent litigation. A certain degree of consistency and uniformity of patent decisions might be expected from such a court.

In the meantime it is probable that in the course of the further litigation arising over this process, the Supreme Court may be convinced that its decision was based upon a false assumption as to the existence of a "critical proportion, a fraction of 1 per cent of oil," and sustain the Court of Appeals' verdict, which was based upon a conception of facts substantiated by the operations of large mills." A. B. C.

Chemical Credits*

By Ellwood Hendrick

The late J. P. Morgan said that if a man had character he would not hesitate to lend him a million dollars without security, but that if he knew him to be deficient in this respect no amount of security would enable the man to borrow money from him. That was a pretty broad statement, but it indicates the nature of credit. Credit is wealth, if you please, but it is of a kind that cannot be obtained ready made. It is, in a sense, an article of barter, because nothing is so easy for a man to trade away as his credit. And yet, it is not merchandise, because the man to whom the original owner trades his credit gets nothing in return but experience. Some kinds of experience may be transformed into credit, but not all. Credit-experience is not exactly a reversible reaction.

Chemical credits are needed, but they are not thoroughly established. Their position is something like that of a St. Louis man, going into a Boston bank to borrow money on Australian securities. Everything is all right except that the transaction does not go through.

The banker does not know the security and he does not know the man. And when we consider how little chemists are known among bankers the problem of the man without a pull is really bewildering when it comes to launching an enterprise.

The business practices of what for want of a better name is called private banking, or sometimes investment banking, have curious psychological sequelæ. Information being the life of the business, it is likely to be secret, and this makes the private banker secretive. On the other hand, among themselves private bankers are gregarious, and they hate to go it alone. It is their habit to invest in series or *en cascade*, so that when two or three leaders subscribe to the underwriting of an enterprise others are likely to follow without much examination. Subscription books close, and there is always the danger that one may be too late. Indeed, there sometimes appears to be as much worry and agony of spirit borne by a banker who invests some money on his own judgment successfully as when he loses the same sum along with the leading houses in the financial district. He dreads solitude in trouble.

The problem, then, in financing an enterprise, is to establish to the satisfaction of one and preferably more than one banker, the merit of the undertaking and the character and ability of the men in charge. Now it is not given to us in youth, as a rule, to select the class at college or the fraternity to which belongs the prospective banker whom we shall want to approach twenty years or more later. It is not given to all of us to live in the same neighborhood as those with funds to invest at the time that we are in the market, and there are a thousand reasons why we may not adjoin or share in opera boxes. The social side of business, however, while still of great weight, is not the sole basis of credit.

The first step in the line of credit is the commercial

*An after-dinner address delivered at the banquet of the American Institute of Chemical Engineers on Jan. 11, 1917.

report, and even here the chemical enterprise is in a bad way. There may be commercial agencies that know how to get the details about an undeveloped or unusual chemical industry and correlate them and get the professional and business records of the men engaged in it, but I have yet to see one. The fact is to make a good, exhaustive report on such an enterprise takes not only time, but chemical knowledge and understanding, and this is just what seems to be lacking. There is, however, no reason why this should not be done. The machinery for gathering full information as to the character and ability of men is at hand in the commercial agencies, and so is that for gleaning information as to the market for special products all over the country. The only thing lacking is chemical direction. Under this there would be gathered and correlated, in addition to the usual information, the very things that it takes a chemical engineer to find out. To the uninformed man location, raw materials, processes and products mean little more than nothing. The chemist can put meaning into them.

How can this be brought about? How can there be established a means for an investor or investors' agent to secure a reliable report on new and changing chemical establishments? How can he get one that he can understand from a source that he knows and on the word of which he is accustomed to determine his credits?

I venture the belief that two or three afternoon sessions of two or three of the right chemical engineers with a couple of sound bankers who have experience in the development rather than the promotion of new enterprises, together with the proper authorities of a mercantile agency that wanted to do this thing, could establish a type of report and lay the foundation of chemical credits. The needful things are: desire by the mercantile agency to do this thing and a willingness on its part to pay for chemical information. I think the chemical engineers and the bankers would gladly contribute time and thought to bring this about.

Coming Meetings and Events

American Paper and Pulp Association, Technical Association, New York, Feb. 6, 7 and 8, 1917.

Joint meeting of New York Section of American Electrochemical Society, American Chemical Society and Society of Chemical Industry, Rumford Hall, Chemists' Club, New York, Feb. 9, 1917.

American Institute of Mining Engineers, annual meeting, New York, Feb. 19-22, 1917.

Program of New York Meeting of American Institute of Mining Engineers

The one hundred and fourteenth meeting of the American Institute of Mining Engineers will be held in New York City, Monday, Feb. 19, to Thursday, Feb. 22, inclusive. A most attractive program has been prepared including the usual technical sessions and entertainment features.

Monday evening will be "College Reunion Night" in the assembly rooms of the Engineering Societies' Building, at 8:30 p. m. Light refreshments and "smokes" will be served. Impromptu addresses will be made with occasional moving pictures of a non-technical character, and other features will be provided to liven things up.

The annual dinner will be held at the Astor on Tuesday evening.

On Wednesday evening a lecture will be given on colored moving pictures and on Thursday an all day excursion will be made to West Point on a special train. The condensed program and part of the technical program follow:

Special entertainment features will be provided for the ladies as usual.

SUMMARIZED PROGRAM

MONDAY, FEB. 19, 1917

9.00 a.m. to 5.00 p.m.—Registration at Institute Headquarters.
10.00 a.m.—Simultaneous Sessions on Geology and on Metallography.
12.30 p.m.—Luncheon at Engineering Societies' Building.
2.00 p.m.—Simultaneous Sessions on Petroleum and Gas and on Milling and Smelting.
8.00 p.m.—College Reunion Night.

TUESDAY, FEB. 20, 1917

10.30 a.m.—Annual Business Meeting followed by Technical Session.
12.30 p.m.—Luncheon at Engineering Societies' Building.
2.00 p.m.—Simultaneous Sessions on Iron Blast Furnace Practice and on Flotation.
6.30 p.m.—Annual Dinner at Hotel Astor, followed by Dancing.

WEDNESDAY, FEB. 21, 1917

10.00 a.m.—Session on the Manufacture of Iron and Steel.
12.30 p.m.—Luncheon at Engineering Societies' Building.
2.00 p.m.—Simultaneous Sessions on Metallography and Heat Treatment of Steel and on Mining Methods.
8.00 p.m.—Entertainment and Lecture at Engineering Societies' Building.

THURSDAY, FEB. 22, 1917

All-day excursion by special train to West Point.
(Exhibition horseback riding, inspection of buildings, etc.)

TECHNICAL SESSIONS

MONDAY, FEB. 19, 1917

10.00 a.m.—Session on Metallography.

Grain Growth Phenomena in Metals. By Zay Jeffries.
On Grain Growth. By Henry M. Howe.
Recrystallization after Plastic Deformation. By Henry M. Howe.
Tungsten and Molybdenum Equilibrium Diagram, and System of Crystallization. By Zay Jeffries.
The System Tungsten-Molybdenum. By Frank Alfred Fahrenwald.

2.00 p.m.—Session on Milling and Smelting.

Magnetic Concentration of Low-Grade Magnetic Iron Ore. By S. Norton and S. Le Fevre.
An Investigation on Rock Crushing Made at McGill University. By John W. Bell.
Countercurrent Decantation. By Luther B. Eames.
The Function of Alumina in Slags. By Carl Henrich.
A Method for Measuring the Viscosity of Blast-Furnace Slag at High Temperatures. By Alexander L. Feild.
Matte Granulation at Herculaneum, Mo. By S. Paul Lindau and Henry B. Smith.

TUESDAY, FEB. 20, 1917

10.00 a.m.—Session on Non-Metallic Minerals.
(Following Annual Business Meeting.)

A Study of the Silica Refractories. By J. Spotts McDowell.
The Genesis of Asbestos and Asbestiform Minerals. By Stephen Taber.
The Conservation of Phosphate Rock in the United States. By W. C. Phalen.

2.00 p.m.—Session on Iron Blast-Furnace Practice

Dry-Hot versus Cold-Wet Blast-Furnace Gas. By Linn Bradley, H. D. Egbert and W. W. Strong.
Some Suggestions Regarding Construction of Hot Blast Stoves. By Linn Bradley, H. D. Egbert and W. W. Strong.
Calculations with Reference to the Use of Carbon in Modern American Blast Furnaces. By Henry Phelps Howland.
Potash as a By-Product from the Blast Furnace. By R. J. Wysor.

2.00 p. m.—Session on Flotation

Notes on Flotation—1916. By J. M. Callow.

WEDNESDAY, FEB. 21, 1917

10.00 a.m.—Session on the Manufacture of Iron and Steel.

The Seasoning of Castings. By Richard Moldenke.
Significance of Manganese in American Steel Metallurgy. By. F. H. Willcox.
Roll Scale as a Factor in the Bessemer Process. By A. Patton and F. N. Speller.

Temperature Measurements in Bessemer and Open-hearth Practice. By George K. Burgess.
The Manufacture of Weldless Steel Tires for Locomotives and Car Wheels. By Guilliaem Aertsen.
2.00 p. m.—Session on Metallography and Heat-Treatment of Steel
Notes on the Heat Treatment of High-Speed Steel Tools. By A. E. Bellis and T. W. Hardy.
Effect of Time in Reheating Hardened Steel Below the Critical Range. By C. R. Hayward and S. S. Raymond.
Erosion of Guns—The Hardening of the Surface. By Henry Fay.
The Effect of Sulphur on Low-Carbon Steel. By Carle R. Hayward.
A Method for Distinguishing Sulphides from Oxides in the Metallography of Steel. By George F. Comstock.

Symposium on the Smelter Smoke and Fume Problem

Three interesting papers on the smoke and fume problem were presented on Friday evening, Jan. 26, at a joint meeting of the New York Sections of the American Electrochemical Society and American Institute of Mining Engineers, held at the Machinery Club.

Mr. LIGON JOHNSON, consulting attorney for the International Nickel Company, and the American Smelting & Refining Company, was the first speaker. He outlined in a very interesting manner the whole legal history of the smoke and fume problem, and then explained the large amount of experimental work done by the American Smelting & Refining at Salt Lake City and other points, in determining the actual extent of the harm done by waste smelter gases to plant life. It was found that all the harm done to plant life was due to SO_3, or mixtures of SO_2 and SO_3, when the plants are in leaf. The visible fume was found to have little effect, it being the invisible fume which does the damage. High stacks and hot exit gases are recommended for visual clearance.

Mr. W. W. STRONG gave a very interesting talk on "Theoretical Aspects of Electrical Precipitation," explaining the corona discharge, electrical wind, and showing just how the precipitation is accomplished. His talk was illustrated with some interesting slides.

Mr. LINN BRADLEY discussed the latest developments in the use of the Cottrell process. One of the most interesting points brought out by him was the necessity of having conditions in all the tubes the same, *i.e.*, regarding each tube in a several tube unit, as a single tube and keeping the conditions in each tube the same as found successful in preliminary experiments, which are made in a single tube. Mr. Bradley concluded his part of the program with some interesting moving pictures of recent Cottrell installations, in connection with brass melting, slate grinding, and smelting.

Both the dinner and the technical session were well attended, there being about 200 present.

Current News and Notes

Local Refining of Metals Planned in Canada.—It is expected that a government bill will be introduced at the approaching session of Parliament in Ottawa, which will provide aid by bounty or tariff for the increased refining of lead, copper and zinc in Canada.

Rubber Club Holds Annual Meeting.—The annual meeting and banquet of the Rubber Club of America was held at the Waldorf-Astoria, New York City, on Monday, January 8. Divisional meetings and business meetings were held during the day and the banquet at 6:30 p. m. The principal speakers at the banquet were Ex-President William H. Taft, Colonel Samuel P. Colt, president of the United States Rubber Company, and Samuel McRoberts, vice-president of the National City Bank, the latter substituting for Frank A. Vanderlip, president of the National City Bank. It had been planned to have a symposium on crude rubber to take up the question of insuring a supply of crude rubber to the country at all times, but there were so many other functions that this had to be postponed to a later date.

Foreign Trade Convention.—The Fourth National Foreign Trade Convention of the National Foreign Trade Council will be held at the William Penn Hotel, Pittsburgh, Pa., January 25, 26 and 27, 1917. Many important questions will be discussed such as the following: Conditions in foreign markets after the war, and the measures necessary to safeguard American foreign trade, as well as the foreign trade aspect of the American tariff system; co-operation in foreign trade development; the American merchant marine; foreign investment of American capital as an aid to oversea commerce, and problems of the smaller manufacturer and merchant.

Course for Prospectors at University of Utah.—The School of Mines and Engineering of the University of Utah, Salt Lake City, has established a course for prospectors, which will be given this winter during the four weeks from Jan. 8 to Feb. 3. The course will cover the fundamentals of geology, mineralogy, mining and the metallurgical treatment of ores. Professor Robert S. Lewis is in charge of the mining department.

Meeting of Mining and Metallurgical Society.—The annual meeting of the Mining and Metallurgical Society of America was held at the Engineers' Club, Jan. 9. The officers elected for the coming year are W. R. Ingalls, president; Waldemar Lindgren, vice-president; Louis D. Huntoon, secretary-treasurer. The annual gold medal of the Society was awarded to E. P. Mathewson for his achievements in non-ferrous metallurgy. Action was taken endorsing Belgian Kiddies, Ltd., and David H. Browne spoke on Mr. Hoover's work and urged greater support for this movement. Mr. George S. Rice of the Bureau of Mines spoke on the Joseph A. Holmes Safety Association and Mr. H. W. DuBois showed some interesting mining pictures of Alaska.

The Colorado Section of the A. I. M. E. held its annual meeting on January 15, 1917, at the University Club in Denver. The following officers were elected for the coming year: Chairman, Chas. Loughridge; vice-chairman, George M. Taylor; directors, Fred A. Bostwick and P. M. McHugh; secretary and treasurer, Fred Carroll. The meeting was non-scientific; the program involved the following numbers of note: Address by L. D. Ricketts, president of the A. I. M. E., over long-distance telephone; "Flotation Exposed and Explained," by H. C. Parmelee, and "The Latest Practice in Cyanide Milling," by T. B. Stearns. Each member present at the banquet had a telephone at his place so as to be sure to hear Dr. Ricketts' voice. Dr. Ricketts' proxy was Mr. Stearns, located in an adjoining room. Most of the crowd were fooled. Mr. Parmelee showed, by very elaborate tests, the value of the flotation process. The experiments consisted in proving once and for all that cork will sink and galena will float. To demonstrate the latest practice in cyaniding, Mr. Stearns made use of the celebrated Metallurgical Cow. The meeting was a success from start to finish and all the members left on their homeward trip thoroughly convinced that both flotation and the new cyanide practice were here to stay.

The Calculation of Lead Blast Furnace Charges—II.

By Boyd Dudley, Jr.

(*Concluded from page* 93)

PROBLEM II.

Materials of compositions shown in the following table are to be smelted in the lead blast furnace.

Material	H_2O, Per Cent	Pb, Per Cent	Cu, Per Cent	SiO_2, Per Cent	Fe, Per Cent	Mn, Per Cent	CaO, Per Cent	MgO, Per Cent	S, Per Cent
D. and L. sinter	0.0	37.20	1.35	17.3	18.4	2.1	10.3	1.2	4.37
Silicious mixture	4.7	5.35	0.65	50.4	10.2	1.1	5.8	0.0	5.28
Pyrite cinder ..	2.3	0.0	0.38	10.6	58.2	0.0	2.3	0.0	1.87
Lime stone ...	4.2	0.0	0.0	6.5	5.3	0.0	43.2	3.2	0.43
Coke		0.0	0.0	5.2	1.2	0.0	1.1	0.0	1.21

Conditions and assumptions: The supplies of D. and L. (Dwight and Lloyd) sinter and of the silicious ore mixture are such that these two materials must be charged in equal quantities to the furnace. With them enough pyrite cinder, limestone, and coke are to be smelted to conform to the following assumed conditions.

It is desired to produce a slag that will contain silica 32 per cent, ferrous oxide 38 per cent, and lime 20 per cent, leaving 10 per cent to be formed by the minor constituents.

The amount of coke is to be 14 per cent of the charge.

Assume that 20 per cent of the sulphur charged to the furnace will escape with the gases, that the slag produced will analyze 1.0 per cent of sulphur, and that the remaining sulphur will form matte containing 23.0 per cent of sulphur and 46.0 per cent of iron. Assume also that all of the copper of the charge will enter the matte, and that sulphur, iron, copper, and lead will constitute 90.0 per cent of the matte as it is produced.

Assume that 4.0 per cent of the lead on the charge will be volatilized and escape with the furnace gases, that the slag will analyze 0.70 per cent of lead, and that the bullion produced will contain 97.0 per cent of lead.

Required: a—Determine the amount of pyrite cinder, of limestone, and of coke to be charged with 1000 lb. of D. and L. sinter and 1000 lb. of the silicious mixture, dry weights being considered.

b—Calculate the wet weight of each material to be employed in making an 8000 lb. charge, exclusive of the coke. What amount of coke should accompany such a charge?

c—What will be the matte fall, *i. e.*, what per cent will the matte be of the charge that produces it? Calculate the approximate composition of the matte.

d—What will be the bullion fall, *i. e.*, what per cent of the charge is the bullion that it produces? Compare this with the per cent of lead on the charge.

Notes: In order to secure uniformity it is customary to make chemical analyses on samples that have been dried at a constant temperature, say 105° C. The loss in weight at this temperature is generally reported as moisture, and the amounts of the determined constituents are calculated as percentages of the dry weight. The moisture, on the other hand, is calculated as a per cent of the wet weight. The reason for this procedure should be evident. When the materials that enter into a furnace charge are weighed, the moisture that each contains has to be taken into account, and this can best be done by deducting the determined percentage of moisture in terms of the wet weight. There is thus left the net or dry weight, to which the various percentages of the chemical analysis apply.

The coke analysis given in the table is based upon the air dried weight, which is the one generally employed unless the coke is shipped or stored under conditions that may expose it to excessive wetting.

It will be observed that among the chemical constituents specified in the table there are manganese and magnesia in addition to those considered in the previous problem. The occurrence of these is a quite common thing, and they are generally taken into account in the following manner:

The atomic weight of manganese is 54.93, while that of iron is 55.84. Furthermore, the chemical characteristics of the two elements have much in common. Therefore, when manganese is present in not too great amounts, it may be considered as having the same chemical effect as iron, and the amount of one may be added directly to the amount of the other. It is also customary to consider the atomic weight of iron or of combined iron and manganese as 56 rather than to employ the more exact figure 55.84. This is a justifiable approximation and produces a simple ratio between iron and ferrous oxide,

$$Fe : FeO = 56 : 72 = 7 : 9.$$

This relationship was employed in the previous problem and will be employed in this and the succeeding one.

In a similar manner magnesia may be considered as having much the same effect as lime. But owing to the difference between the molecular weights of these compounds, the magnesia is the more effective of the two as a basic slag constituent, and if, for the sake of simplicity, it is desired to add magnesia to lime and to consider both oxides as lime, the magnesia must be given its proper lime value. This is done on the assumption that a molecule of magnesia has the same chemical effect in the slag as does a molecule of lime. Hence, the molecular weight of magnesia being 40 and that of lime being 56, one unit of magnesia is equivalent to $56 \div 40 = 1.4$ units of lime.

While the calculation of magnesia as lime according to the above ratio is a justifiable short cut, it introduces an alteration of the original set of assumed conditions that should be pointed out. It was assumed that silica, ferrous oxide, and lime would together constitute 90 per cent of the slag produced, the remainder being composed of alumina, zinc, sulphur, lead, etc. But now it is proposed to consider each unit weight of magnesia present as 1.4 units of lime, and still to calculate the silica, ferrous oxide, and lime thus determined as aggregating 90 per cent of the slag. It is evident that percentages and molecular weights are here being combined in a manner that is theoretically incorrect. But unless the amounts of magnesia in the charged materials are high, the error thus introduced is of little practical importance, and the calculations are greatly simplified by this procedure.

Solution: As before, it is well to calculate the slag ratios at the outset, taking a unit weight of silica as the standard. For each pound of silica in the slag there will be other constituents as follows:

$$\text{Iron} = \frac{38\%\ FeO}{32\%\ SiO_2} \times \frac{7}{9} \text{ (ratio Fe to FeO)} = 0.924 \text{ lb.}$$

$$\text{Lime} = \frac{20\%\ CaO}{32\%\ SiO_2} = 0.625 \text{ lb.}$$

$$\text{Sulphur} = \frac{1\%\ S}{32\%\ SiO_2} = 1/32 \text{ lb.}$$

That is, the amounts of silica, iron, lime, and sulphur in the slag should be present in accordance with the relation:

Silica : Iron : Lime : Sulphur = 1.00 : 0.924 : 0.625 : 1/32.

Before proceeding to draw up a charge sheet the analyses of the different materials can be simplified according to the notes outlined above. Thus in the D. and L. sinter:

18.4% Fe + 2.1% Mn = 20.5% Fe, and
10.3% CaO + (1.2% MgO × 1.4) = 12.0% CaO.
In the silicious ore mixture:
10.2% Fe + 1.1% Mn = 11.3% Fe.
In the limestone:
43.2% CaO + (3.2% MgO × 1.4) = 47.7% CaO.

The various materials with their simplified analyses may now be entered on a charge sheet, which may conveniently have the following form. In this case the lead and copper figures may be omitted for the present, and since the D. and L. sinter and the silicious mixture are to be smelted in equal quantities, 1000 lb. of each may be entered at once on the sheet. This has been done in lines *a* and *b*, and the amounts of the constituents thus provided have been calculated and entered in their proper places.

Charge Sheet, Problem II.

		Silica		Iron		Lime		Sulphur	
Material	Dry Wt.	Per Cent	Wt.	Per Cent	Wt.	Per Cent	Wt.	Per Cent	Wt.
a—D. & L. sint.	1,000	17.3	173	20.5	205	12.0	120	4.37	43.7
b—Silic. mixtr.	1,000	50.4	504	11.3	113	5.8	58	5.28	52.8
c—T't'ls a & b	2,000	...	677	...	318	...	178	...	96.5
d—Pyrite cind.	950	10.6	101	58.2	553	2.3	22	1.87	17.8
e—Limestone.	680	6.5	44	5.3	36	47.7	324	0.43	2.9
f—Coke	508	5.2	26	1.2	6	1.1	6	1.21	6.2
g—First trial totals....	....	...	848	...	913	...	530	...	123.4
h—T't'ls a & b	2,000		677		318		178		96.5
i—Pyrite cind.	985		104		573		23		18.4
j—Limestone..	685		45		36		327		2.9
k—Coke	515		27		6		6		6.2
l—Second trial totals ...			853		933		534		124.0

The amounts of silica, iron, lime, and sulphur in the D. and L. sinter and in the silicious mixture may now be added. The respective totals have been entered in line *c* of the charge sheet. The problem has now resolved itself into a very simple form. It is only necessary to provide pyrite cinder, limestone, and coke in proper quantities for the amounts of various constituents shown in line *c* of the sheet. The method of making estimates of these quantities and of finally balancing the charge is as follows:

To estimate the amount of pyrite cinder, consider the totals of line *c*. Of the 96.5 lb. of sulphur present 80 per cent will remain in the furnace and enter the matte and slag. The exact amount of this that will ultimately enter the slag is a matter of speculation. But it is seen that the silica of line *c* amounts to 677 lb., and according to the assumed slag ratio each unit of silica will be accompanied in the slag by 1/32 unit of sulphur. Therefore, considering the material of line *c* alone it is seen that:

Sulphur to matte and slag = 96.5 lb. × 0.80 = ...	77.2	lb.
Sulphur to slag = 677 lb. ÷ 32 = ...	21.2	lb.
Sulphur to matte after deducting gas and slag losses = ..	56.0	lb.
Iron present for slag and matte = ...	318	lb.
Iron required for matte = 56 lb. × 2 = ...	112	lb.
Iron available for slag = ...	206	lb.
Silica present for slag = ...	677	lb.
Silica provided with iron = 206 lb. ÷ 0.924 = ...	223	lb.
Silica of line *c* in excess of iron = ...	454	lb.

It is evident that there is 454 lb. of silica in line *c* that will require iron from an external source. Now consider the analysis of the pyrite cinder. The 10.6 per cent of silica present therein will require approximately 10 per cent of iron in forming slag. There is also present 1.87 per cent of sulphur, a part of which will require iron in forming matte. A quick mental estimate shows that the amount of iron so required will not be less than 2 per cent. Hence approximately 12 per cent of the iron of the pyrite cinder will be required by the silica and sulphur of that material. There remains practically 46 per cent of available iron, which may be employed in supplying the deficit of iron in line *c*.

The pyrite cinder required to furnish free iron for 454 lb of silica is

$$\frac{454 \text{ lb.} \times 0.924}{0.46} = 913 \text{ lb.}$$

This amount of pyrite cinder would provide the necessary iron for the materials of lines *c* and *d*, but these materials are not to be smelted alone. There must still be added certain amounts of limestone and coke, both of which contain silica and also sulphur. Inspection of the limestone analysis shows that iron and silica are fairly well balanced in this material, although there is a small amount of sulphur, which the iron may not fully cover. On the other hand, the coke is seen to contain a large excess of silica over iron and also to contain considerable sulphur. It is therefore clear that the 913 lb. of cinder estimated above will prove insufficient to provide iron for the entire charge. The amount to be added to 913 lb. of pyrite cinder in order to allow iron for the silica and sulphur of the coke might be estimated by a process similar to that which has been followed up to the present. But in general such an estimate will consume more time than will an arbitrary addition to the estimated amount and a trial of the charge to determine whether or not it is properly balanced. For instance, suppose that in this case 950 lb. of pyrite cinder is entered in line *d*. Understand, this is a purely arbitrary increase over the amount first estimated. It may be too much or too little. Judgment and previous experience may be well used in this case, although they are not in any way essential. Calculate and enter the constituents of 950 lb. of pyrite cinder in their respective spaces in line *d*.

Now proceed to estimate the amount of limestone as follows. In lines *c* and *d* there are present 778 lb. of silica and 200 lb. of lime

Lime requirement of silica = 778 lb. × 0.625 = ...	486	lb.
Lime already present = ...	200	lb.
Lime required to supply deficit in lines *c* and *d* = ...	286	lb.

Considering the analysis of the limestone, 6.5 per cent of silica will require 6.5 × 0.625 = 4.1 per cent of lime. This leaves 47.7 — 4.1 = 43.6 per cent of lime in excess of that required by the silica of the limestone itself, *i.e.*, 43.6 per cent of available lime. The amount of limestone required to provide 286 lb of available lime is therefore

$$\frac{286 \text{ lb.}}{0.436} = 656 \text{ lb.}$$

This will provide sufficient lime for everything on the charge except the coke, and the analysis of this material shows that there is a large excess of silica in it above the lime that it contains. Here again an estimate of the amount of limestone to add for the purpose of providing lime for the coke could be attempted, but suppose 680 lb. of limestone is entered for a first trial. This is an arbitrary increase to be sure, but it will not be far wrong and will probably be productive of a saving of time. Calculate and enter in line *e* the amounts of constituents in 680 lb. of limestone.

The coke may now be calculated and entered. The charge as it now stands consists of 1000 lb. of D. and L. sinter; 1000 lb. of silicious mixture; 950 lb. of pyrite cinder, and 680 lb. of limestone, making a total of 3630 lb. The amount of coke to be employed is 14 per cent of the charge. Hence

$$\text{Coke} = 3630 \text{ lb.} \times 0.14 = 508 \text{ lb.}$$

Enter this with its constituents in their proper places in line *f*.

The entire charge as thus estimated may now be

tested to determine whether or not the materials are present in proper proportions. The method of performing this operation is as follows.

Add the amounts of silica, iron, lime, and sulphur present on the charge, and enter the totals in line *g* of the sheet. Considering the figures therein,

Sulphur to matte and slag = 123.4 lb. × 0.80 =	98.8 lb.
Sulphur to slag = 848 lb. ÷ 32 =	26.5 lb.
Sulphur to matte =	72.3 lb.
Iron on charge =	913 lb.
Iron to matte = 72.3 lb. × 2 =	145 lb.
Iron to slag =	768 lb.
Iron required by silica = 848 lb. × 0.924 =	783 lb.
Deficit of iron =	15 lb.
Lime on charge =	530 lb.
Lime required by silica = 848 lb. × 0.625 =	530 lb.

It is thus seen that the charge as first estimated is properly balanced with respect to lime but lacks iron to the extent of 15 lb. This will necessitate an addition to the pyrite cinder, the amount of which will be approximately

$$\frac{\text{15 lb. deficit of iron}}{\text{0.46 available iron in cinder}} = 33 \text{ lb.}$$

For convenience this may be increased to 35 lb., making the second estimate of pyrite cinder 950 lb. + 35 lb. = 985 lb.

In order to preserve a clean and neat sheet and at the same time to have the result of each trial in evidence it is better not to erase the first estimates, but to extend the charge sheet downward as has been done. In line *h* the totals of lines *a* and *b* have again been entered. In line *i* the new amount of pyrite cinder is entered, and the amounts of its constituents are computed and entered in their proper places.

Now for the limestone, in the first charge the lime was seen to be balanced to the nearest pound, but the addition of 35 lb. to the pyrite cinder will add silica to the charge in excess of the lime added, and this balance of lime will be disturbed. Hence, for a second trial the limestone should be increased as well as the pyrite cinder. Inspection of the cinder analysis with reference to silica and lime shows that an increase of 35 lb. in this material will introduce about 2 lb. of silica in excess of lime, and this may be corrected by adding 5 lb. to the limestone. Therefore, for a second trial the limestone should be increased from 680 lb. to 685 lb.

These additions to the charge will necessitate a corresponding increase in the coke, the new weight being

$$(2000 + 985 + 685) \text{ lb.} \times 0.14 = 3770 \text{ lb.} \times 0.14 = 515 \text{ lb.}$$

Entering the 685 lb. of limestone in line *j* and 515 lb. of coke in line *k* yields the second completed charge, which can be tested as before.

Considering the totals entered in line *l*,

Sulphur to matte and slag = 124 lb. × 0.80 =	99.2 lb.
Sulphur to slag = 853 lb. ÷ 32 =	26.6 lb.
Sulphur to slag =	72.6 lb.
Iron on charge for matte and slag =	933 lb.
Iron required by matte = 72.6 lb. × 2 =	145 lb.
Iron for slag =	788 lb.
Iron required by silica = 853 lb. × 0.924 =	788 lb.
Lime on charge =	534 lb.
Lime required by silica = 853 lb. × 0.625 =	533 lb.
Excess of lime on charge over requirement =	1 lb.

This charge may be considered as satisfactory, and the finished charge will consist of D. and L. sinter 1000 lb., silicious ore mixture 1000 lb., pyrite cinder 985 lb., limestone 685 lb., and coke 515 lb. These are dry or net weights, and in those cases where the material contains a known amount of moisture the proper allowance must be made.

Requirement *b* in the statement of the problem asks for the wet weights of these materials to be used in an 8000 lb. charge. First let the wet weights of materials entering the charge as already determined be calculated, bearing in mind that the percentages of moisture specified in the analyses are based upon the wet weights. Hence

$$\text{Wet weight} = \text{Dry weight} \times \frac{100}{100 - \text{per cent moisture on dry weight}}$$

The actual or wet weights required to form the charge as calculated above are as follows:

Material	Dry Weight		Wet Weight
D. and L. sinter	1,000 lb.		1,000 lb.
Silicious mixture	1,000 lb.	$\times \frac{100}{100 - 4.7} =$	1,050 lb.
Pyrite cinder	985 lb.	$\times \frac{100}{100 - 2.3} =$	1,010 lb.
Limestone	685 lb.	$\times \frac{100}{100 - 4.2} =$	715 lb.
Coke	515 lb.		515 lb.

The total of the wet weights exclusive of the coke is 3775 lb. and in order to determine the amount of each material to use in an 800 lb. charge it is simply necessary to multiply each by the factor

$$\frac{8000}{3775} = 2.12$$

Thus

D. and L. sinter = 1,000 lb. × 2.12 =	2,120 lb.
Silicious mixture = 1,050 lb. × 2.12 =	2,225 lb.
Pyrite cinder = 1,010 lb. × 2.12 =	2,140 lb.
Limestone = 715 lb. × 2.12 =	1,515 lb.
Total	8,000 lb.
Coke = 14 per cent of dry charge = 515 lb. × 2.12 =	1,090 lb.

Requirement *c* in the statement of the problem asks for a calculation of the matte fall and the approximate composition of the matte, it being assumed that all of the copper on the charge will enter the matte, and that this together with iron, lead and sulphur will constitute 90 per cent of the matte produced. It is also assumed that the matte as produced will contain 23 per cent of sulphur and 46 per cent of iron.

For convenience in making these calculations let the last set of figures entered on the charge sheet be considered, *i.e.*, the finished charge as it was determined in terms of dry weights. In balancing the charge the last time it was found that 72.6 lb. of sulphur would enter the matte. If this constitutes 23.0 per cent of the matte produced, the weight of matte from this charge will be

$$\frac{72.6 \text{ lb.}}{0.230} = 316 \text{ lb.,}$$

and the matte fall will be

$$\frac{\text{Weight of matte} \times 100}{\text{Weight of charge producing matte}} = \frac{316 \times 100}{3670} = 8.61 \text{ per cent.}$$

Now the amount of copper on the charge is as follows:

1,000 lb. D. and L. sinter × 0.0135 =	13.5 lb.
1,000 lb. silicious ore mixtures × 0.0065 =	6.5 lb.
985 lb. pyrite cinder × 0.0038 =	3.7 lb.
Total =	23.7 lb.

Assuming that all of this copper will enter the matte, the matte will contain

$$\frac{23.7 \times 100}{316} = 7.5 \text{ per cent copper.}$$

If sulphur, copper, iron, and lead constitute 90.0 per cent of the matte, then the lead will be

$$90.0 - (23.0 + 46.0 + 7.5) = 90.0 - 76.5 = 13.5 \text{ per cent.}$$

So the matte as thus calculated will consist of

	Per Cent	Weight
Sulphur =	23.0 = 316 lb. × 0.230 =	72.6 lb.
Iron =	46.0 = 316 lb. × 0.460 =	145 lb.
Copper =	7.5 = 316 lb. × 0.075 =	23.7 lb.
Lead =	13.5 = 316 lb. × 0.135 =	42.6 lb.
Miscel. =	10.0 = 316 lb. × 0.100 =	31.6 lb.

Requirement *d* in the statement asks for a calculation of the bullion fall and a comparison of this with the per cent of lead on the charge. It is assumed that 4.0 per cent of the lead charged to the furnace is lost as dust and fume, that the slag will contain 0.70 per cent of lead, and that the base bullion produced will contain 97.0 per cent of lead.

The amount of lead on the charge is

1,000 lb. D. and L. sinter × 0.372 =	372 lb.
1,000 lb. silicious ore mixture × 0.0535 =	53.5 lb.
Total =	425.5 lb.

Hence the lead on the charge is

$$\frac{425.5 \times 100}{3670} = 11.6 \text{ per cent.}$$

The bullion fall is calculated by deducting the various amounts of lead that do not enter the bullion from that present. Thus

Lead lost to stack as dust and fume = 425.5 × 0.040 =	17.0 lb.
Lead entering matte =	42.6 lb.
Lead lost in slag = silica × $\frac{0.70}{32}$ = 853 lb. × 0.0218 =	18.6 lb.
	78.2 lb.
Lead present on charge =	425.5 lb.
Lead to stack, matte and slag	78.2 lb.
Lead entering bullion	347.3 lb.

If this lead constitutes 97.0 per cent of the bullion produced, then the amount of bullion from this charge is

$$\frac{347.3 \text{ lb.}}{0.970} = 358 \text{ lb.,}$$

and the bullion fall is

$$\frac{358 \times 100}{3670} = 9.75 \text{ per cent.}$$

In concluding this problem it should be remarked that the calculation of matte composition in advance is not, as a rule, a very practicable or necessary operation. It is given here, together with the bullion calculation, more as an exercise to bring before the student certain facts as to matte and bullion constitution, lead losses, etc., than for any other reason. It is true, however, that the converse of such calculations have frequent application, *i.e.*, the matte, slag, and bullion analyses with their respective production figures are employed in calculations to determine and check the metal losses incidental to the operation. This point will be illustrated in the solution of the next problem.

In the problem just completed the calculations involved, when moisture, manganese, and magnesia are taken into consideration, have been illustrated. For this reason these factors will not be introduced again, and analyses that have presumably been already simplified and are stated in terms of dry weights will be employed hereafter.

PROBLEM III

Materials of compositions shown in the following table are to be smelted in the lead blast furnace.

Material	Lead, Per Cent	Silica, Per Cent	Iron, Per Cent	Lime, Per Cent	Sulphur, Per Cent
D. and L. sinter.	39.50	17.5	20.6	12.5	4.2b
Silicious ore.....	12.30	50.1	10.7	2.3	5.38
Iron ore.....	0.0	12.6	55.3	1.7	1.94
Limestone	0.0	7.5	4.2	46.8	0.0
Coke	0.0	5.2	1.2	1.1	1.32

Conditions and assumptions.—It is desired to have 12.0 per cent of lead on the finished charge, *i.e.*, the two lead bearing materials are to be so proportioned that 12.0 per cent of the charge including iron ore and limestone, but not including coke, will consist of lead.

It is desired to produce a slag that will contain silica 34 per cent, ferrous oxide 28 per cent, and lime 28 per cent, leaving 10 per cent to be formed by the minor constituents.

The amount of coke is to be 14 per cent of the charge.

Assume that 20 per cent of the sulphur charged to the furnace will escape with the gases, that the slag produced will analyze 1.0 per cent of sulphur, and that the remaining sulphur will form matte containing 23.0 per cent of sulphur and 46.0 per cent of iron.

Assume that when this furnace charge as calculated is actually smelted the matte fall is found to agree with the calculated figure, and an analysis of the matte shows a 12.5 per cent lead content.

Assume that the amount of bullion produced from the charge is 10.3 per cent, and that it shows on analysis 97.0 per cent of lead.

Assume that the slag as produced contains 0.68 per cent of lead.

Required.—(a) Determine the amounts of silicious ore, iron ore, limestone, and coke to be smelted with 1000 lb. of the D. and L. sinter in order to comply with the above outlined conditions.

(b) Calculate the distribution of the lead on the charge among the various products formed, bullion, matte, slag, and flue loss.

Notes.—The condition imposed in this case, that the charge shall contain a definite amount of lead, is one that is frequently encountered in districts where silver-lead smelters have offerings of considerable quantities of low-lead, silicious ores. In such cases ores that are rich in lead are valuable not only for the metal itself, but the lead in such materials may serve as a collector for silver and gold occurring in ores that contain little or no lead. In other words, the ore that is rich in lead is diluted with such a quantity of ore that is low in lead as it will take, and still maintain a given quantity of lead on the furnace charge.

In this case it is required that 12.0 per cent of lead be present, although this does not represent the minimum that might be successfully employed.

There are several methods whereby this problem might be solved. One of the most obvious, and the one that will be here employed, consists of making two separate calculations, the first involving 1000 lb. of the D. and L. sinter with the necessary fluxes and coke, the second involving a like amount of the silicious ore with its necessary fluxes and coke. Thus two charges will be calculated and subsequently combined in the manner required to make lead 12.0 per cent of the final charge.

Solution.—Again the logical starting point is the calculation of the slag ratios, and again a unit weight of silica will be taken as the standard. In a slag of the desired composition the amounts of other constituents present with each pound of silica will be:

Iron = $\frac{28\%\ \text{FeO}}{34\%\ \text{SiO}_2} \times \frac{7}{9}$ (ratio of Fe to FeO) =	0.640 lb.
Lime = $\frac{28\%\ \text{CaO}}{34\%\ \text{SiO}_2}$ =	0.824 lb.
Sulphur = $\frac{1.0\%\ \text{S}}{34\%\ \text{SiO}_2}$ =	1/34 lb.

A charge sheet may now be drawn up according to the following form. The first charge to be calculated involving 1000 lb. of D. and L. sinter will hereafter be designated as Charge A, while the second one involving 1000 lb. of the silicious ore will be designated as Charge B.

CHARGE SHEET, PROBLEM III.

CHARGE A.

	Material	Dry Weight	Silica Per Cent	Silica Wt.	Iron Per Cent	Iron Wt.	Lime Per Cent	Lime Wt.	Sulphur Per Cent	Sulphur Wt.
a	D. & L. sint.	1,000	17.5	175	20.6	206	12.5	125	4.25	42.5
b	Silicious ore	115	50.1	58	10.7	12	2.3	3	5.38	6.2
c	Limestone..	170	7.5	12	4.2	7	46.8	80	0.0	0.0
d	Coke	180	5.2	9	1.2	2	1.1	2	1.32	2.4
e	First trial totals	...	...	254	...	227	...	210	...	51.1
f	D. & L. sint.	1,000		175		206		125		42.5
g	Silicious ore	105		53		11		2		5.7
h	Limestone..	160		11		7		75		...
i	Coke	177		9		2		2		2.3
j	Second trial totals	...		248		226		204		50.5

CHARGE B.

	Material	Dry Weight	Silica Per Cent	Silica Wt.	Iron Per Cent	Iron Wt.	Lime Per Cent	Lime Wt.	Sulphur Per Cent	Sulphur Wt.
k	Silicious ore	1,000	50.1	501	10.7	107	2.3	23	5.38	53.8
l	Iron ore....	650	12.6	82	55.3	359	1.7	11	1.94	12.6
m	Limestone..	1,125	7.5	83	4.2	47	46.8	526	0.0	0.0
n	Coke	388	5.2	20	1.2	5	1.1	4	1.32	5.1
o	First trial totals	...	...	686	...	518	...	564	...	71.5
p	Silicious ore	1,000		501		107		23		53.8
q	Iron ore....	640		81		354		11		12.4
r	Limestone...	1,125		83		47		526		0.0
s	Coke	387		20		5		4		5.1
t	Second trial totals	...		685		513		564		71.3

In calculating Charge A the first thing to enter is 1000 lb. of the D. and L. sinter, together with the amounts of its constituents, in line *a*. Now before entering any further analyses it will be well to consider the figures in line *a* and find out what further materials are needed to complete the charge. From the figures in line *a*,

Sulphur to matte and slag = 42.5 lb. × 0.80 =		34.0 lb.
Sulphur to slag with silica = 175 lb. ÷ 34 =		5.2 lb.
Sulphur to matte after deducting gas and slag losses =		28.8 lb.
Iron present for matte and slag =	206	lb.
Iron to matte with sulphur = 28.8 lb. × 2 =	58	lb.
Iron available for slag =	148	lb.
Iron required by silica = 175 lb. × 0.64 =	112	lb.
Iron excess over silica in 1,000 lb. D. and L. =	36	lb.

This is a new situation. The principal material in Charge A has an excess of iron over that required by its silica and sulphur to form slag and matter. Therefore iron ore will not be needed on this charge, but there is need for a silicious material. The logical thing to use under these circumstances is some of the silicious ore that is to be smelted. The next question is, how much?

In order to estimate the amount of the silicious ore that will be required by the D. and L. sinter it is necessary to consider the amounts of iron, silica, and sulphur in the former. The analysis shows

Sulphur to matte and slag = 5.38 per cent × 0.80 =	4.30 per cent
Sulphur to slag = 50.1 per cent ÷ 34 =	1.47 per cent
Sulphur to matte =	2.83 per cent
Iron present =	10.7 per cent
Iron to matte = 2.83 per cent × 2 =	5.7 per cent
Iron for slag =	5.0 per cent
Silica present =	50.1 per cent
Silica to slag with iron = 5.0 per cent ÷ 0.640 =	7.8 per cent
Silica in excess of iron =	42.3 per cent

It has been shown that 1000 lb. of D. and L. sinter contains 36 lb. of iron in excess of silica, and if silica for this iron is to be supplied from the silicious ore, which has 42.3 per cent of silica in excess of iron, then the amount of silicious ore required will be.

$$\frac{\text{36 lb. of iron}}{\text{0.640 slag ratio iron to silica}} \times \frac{100}{42.3} = 133 \text{ lb.}$$

This then would provide the correct amount of silica for the D. and L. sinter, but the analyses of the limestone and coke show that both of these materials contain silica in excess of iron. Therefore 133 lb. of the silicious ore would provide an excess of silica on the finished charge. For the first trial a smaller amount should be used, say 115 lb. Enter it in line *b* of the charge sheet, entering also the amounts of the constituents of this material in their proper places.

An estimate of the limestone may now be made, taking into account the silica and lime shown in lines *a* and *b*.

Lime required by 233 lb. silica = 233 lb. × 0.824 =	192 lb.
Lime present in lines *a* and *b* =	128 lb.
Lime to be supplied =	64 lb.

In the limestone the 7.5 per cent of silica will require 7.5 × 0.824 = 6.2 per cent of the lime, and this leaves 46.8 — 6.2 = 40.6 per cent of lime in excess of the silica. The amount of limestone required to provide 64 lb. of available lime will therefore be

$$\frac{\text{64 lb.}}{0.406} = 158 \text{ lb.}$$

But this will be insufficient for the entire charge, because the coke is not included in making this estimate, and the coke analysis shows an excess of silica over lime. For the first trial, therefore, let this amount of limestone be raised to 170 lb. Enter this together with its calculated constituents in line *c*.

The coke for the charge as thus determined will be (1000 + 115 + 170) lb. × 0.14 = 1285 lb. × 0.14 = 180 lb. Enter this amount of coke in line *d*, calculating its constituents.

The totals of silica, iron, lime, and sulphur are now entered in line *e*, and the charge is tested as follows. From amounts in lines,

Sulphur to matte and slag = 51.1 lb. × 0.80 =		40.9 lb.
Sulphur to slag = 254 lb. ÷ 34 =		7.5 lb.
Sulphur to matte =		33.4 lb.
Iron on charge for matte and slag =	227	lb.
Iron to matte = 33.4 lb. × 2 =	67	lb.
Iron for slag =	160	lb.
Iron required by silica = 254 lb. × 0.640 =	163	lb.
Deficit of iron =	3	lb.
Lime on charge for slag =	210	lb.
Lime required by silica = 254 lb. × 0.824 =	209	lb.
Excess of lime =	1	lb.

The charge as it stands shows a deficit of iron amounting to 3 lb. and an excess of lime amounting to 1 lb. While this would not be a serious matter in practice, for the present purpose it will be better to correct the condition. The desired change may be effected by cutting the amount of silicious ore on the charge. It will be recalled that this material contains about 42 per cent of silica in excess of iron. The removal of 10 lb. of it from the charge will therefore decrease the amount of free silica by about 4 lb., and this according to the slag ratio will correct the deficit of iron. At the same time a decrease in the silica will destroy the balance of the charge with respect to lime. Consequently, a cut in the limestone will also have to be made. Reasoning in a manner similar to the above shows that this cut should also be about 10 lb.

For the second trial enter 1000 lb. of D. and L. sinter in line *f*, 105 lb. of silicious ore in line *g*, 160 lb. of limestone in line *h*, and 177 lb. of coke in line *i*. The components are to be calculated as usual, totals being entered in line *j*.

Considering these totals,

Sulphur to matte and slag = 50.5 lb. × 0.80 =		40.4 lb.
Sulphur to slag = 249 lb. ÷ 34 =		7.3 lb.
Sulphur to matte =		33.1 lb.
Iron for matte and slag =	226	lb.
Iron to matte = 33.1 lb. × 2 =	66	lb.
Iron for slag =	160	lb.
Iron required by silica = 248 lb. × 0.640 =	159	lb.
Excess of iron =	1	lb.
Lime on charge for slag =	204	lb.
Lime required by silica = 248 lb. × 0.824 =	204	lb.

This works out a little better than the previous trial, though both of them are good, and either would be sufficiently correct.

The amount of lead on Charge A as it was last calculated is

Lead from 1,000 lb. D. and L. sinter = 1,000 lb. × 0.3950 =	395.0 lb.
Lead from 105 lb. silicious ore = 105 lb. × 0.123 =	12.9 lb.
Total =	408 lb.

$$\text{Per cent of lead on Charge A} = \frac{408 \times 100}{1265} = 32.5.$$

Passing now to the calculation of Charge B, the first step consists of entering 1000 lb. of the silicious ore on the charge sheet. It is seen in line *k* with the amounts of its constituents properly entered.

The amount of silica present in this material in excess of iron has already been estimated at 42.3 per cent. Hence, in the 1000 lb. there will be 423 lb. of silica to be provided with iron. Considering the iron ore analysis, the 12.6 per cent of silica will require 12.6 × 0.640 = 8.1 per cent of iron. The 1.94 per cent of sulphur present will require about 2 per cent of iron for matte. There remains 55.3 — 10.1 = 45.2 per cent approximately of iron in excess of the silica and sulphur. The iron ore required for 423 lb. of silica in the silicious ore will therefore be

$$\frac{423 \text{ lb.} \times 0.640}{0.452} = 599 \text{ lb.}$$

As in most of the previous cases, however, this amount of iron ore will not be sufficient for the entire charge, because the limestone and coke are both yet to be added, and both contain an excess of silica over iron. As a first trial let the amount of iron ore be increased beyond this estimate to 650 lb. Enter this amount with its constituents in line *l*.

Now, consider the amounts of silica and lime in lines *k* and *l*.

Lime required by 583 lb. silica = 583 lb. × 0.824 =	480 lb.
Lime present =	34 lb.
Lime to be supplied =	446 lb.

It has already been seen that the limestone contains 40.6 per cent of lime in excess of silica. Hence the limestone required to provide 446 lb. of lime is

$$\frac{446 \text{ lb.}}{0.406} = 1100 \text{ lb.}$$

What is to be done with this? Shall 1100 lb. of limestone be entered on the charge sheet? No, because the coke contains silica in excess of lime, and this amount of limestone would prove insufficient for the entire charge. Let it be increased to 1125 lb. Enter this in line *m* with its calculated constituents.

Coke for this charge will be: (1000 + 650 + 1125) lb. × 0.14 = 2775 lb. × 0.14 = 388 lb. Enter this amount and constituents in line *n*.

Considering the totals of line *o*,

Sulphur to matte and slag = 71.5 lb. × 0.80 =	57.3 lb.
Sulphur to slag = 686 lb. ÷ 34 =	20.2 lb.
Sulphur to matte =	37.1 lb.
Iron on charge for matte and slag =	518 lb.
Iron to matte = 37.1 lb. × 2 =	74 lb.
Iron to slag =	444 lb.
Iron required by silica = 686 lb. × 0.640 =	439 lb.
Excess of iron on charge =	5 lb.
Lime on charge for slag =	564 lb.
Lime required by silica = 686 lb. × 0.824 =	565 lb.
Deficit of lime =	1 lb.

The excess of iron amounting to 5 lb. may be adjusted by cutting 10 lb. from the iron ore. The limestone may be left as it is, because this cut in the iron ore will naturally adjust the 1 lb. deficit of lime by removing silica from the charge.

Amounts for the second trial will therefore be silicious ore 1000 lb., iron ore 640 lb., limestone 1125 lb., and coke (14 per cent) 387 lb. Enter these in lines *p*, *q*, *r*, and *s*, with totals in line *t*.

Considering the totals in the last line,

Sulphur to matte and slag = 71.3 lb. × 0.80 =	57.0 lb.
Sulphur to slag = 685 lb. ÷ 34 =	20.1 lb.
Sulphur to matte =	36.9 lb.
Iron on charge for matte and slag =	513 lb.
Iron to matte = 36.9 lb. × 2 =	74 lb.
Iron to slag =	439 lb.
Iron required by silica = 685 lb. × 0.640 =	438 lb.
Excess of iron =	1 lb.
Lime on charge for slag =	564 lb.
Lime required by silica = 685 lb. × 0.824 =	564 lb.

The charge is satisfactorily balanced.

The amount of lead on Charge B as last calculated is lead from 1000 lb. silicious ore = 1000 lb. × 0.1230 = 123 lb.

$$\text{Per cent of lead on charge} = \frac{123 \times 100}{2765} = 4.45$$

Requirement *a* in the statement of the problem asks for the amounts of silicious ore, iron ore, limestone, and coke to be smelted with 1000 lb. of the D. and L. sinter in order to have present 12.0 per cent of lead on the charge. The per cent of lead on Charge A is 32.5, and that on Charge B is 4.45. In what proportions will A and B have to be mixed to have 12.0 per cent of lead present in the mixture?

Let a = the per cent of Charge A in such a mixture and b = the per cent of Charge B in the mixture. Then

$$a + b = 100$$

and

$$0.325\ a + 0.0445\ b = 12.0.$$

Solving, a = 26.8 per cent, and b = 73.2 per cent.

The weight of Charge A as calculated is 1265 lb. This contains 1000 lb. of the D. and L. sinter. Hence the final charge will weigh

$$\frac{1265 \text{ lb.}}{0.268} = 4720 \text{ lb.},$$

it being necessary to have 26.8 per cent of Charge A in order that the lead may be 12.0 per cent of the charge. Of Charge B there will be required for the final charge 4720 lb. — 1265 lb. = 3455 lb. Since Charge B as calculated weighed 2765 lb., the amount of each material therein to be employed in the final charge may be found by multiplying the original figures by

$$\frac{3455}{2765} = 1.25$$

Thus

Silicious ore,	1,000 lb. × 1.25 =	1,250 lb.
Iron ore,	640 lb. × 1.25 =	800 lb.
Limestone,	1,125 lb. × 1.25 =	1,405 lb.

The final combination of Charges A and B will therefore be as follows:

D. and L. sinter =	1,000 lb.
Silicious ore, 105 lb. + 1,250 lb. =	1,355 lb.
Iron ore =	800 lb.
Limestone, 160 lb. + 1,405 lb. =	1,565 lb.
Total =	4,720 lb.
Coke = 14 per cent of charge =	660 lb.

Requirement *b* in the statement of the problem asks for a calculation of the lead distribution among the various products formed during the smelting operation. These conditions are assumed, that the amount of matte produced is found to agree with the calculated matte fall, that the matte contains 12.5 per cent of lead, that the amount of bullion produced is 10.3 per cent of the charge and contains 97.0 per cent lead, and that the slag produced contains 0.68 per cent lead.

In order to solve this part of the problem it is neces-

sary to employ the final charge as outlined above. The information needed may be conveniently assembled in the following form:

Material	Weight, lb.	Lead, lb.	Silica, lb.	Sulphur, lb.
D. and L. sinter	1,000	395	175	42.5
Siliceous ore	1,355	167	679	72.9
Iron ore	800	...	101	15.5
Limestone	1,565	...	117	...
Coke	660	...	34	8.7
		562	1,106	139.6

The above total figures yield the following:

Sulphur to matte and slag = 139.6 lb. × 0.80 =	111.5 lb.
Sulphur to slag = 1106 lb. ÷ 34 =	32.5 lb.
Sulphur to matte =	79.0 lb.

If this sulphur constitutes 23.0 per cent of the matte, then the amount of matte produced from the charge is

$$\frac{79.0 \text{ lb.}}{0.230} = 343 \text{ lb.}$$

Lead contained in the matte = 343 lb. × 0.125 =	42.9 lb.
Lead in slag = 1,106 lb. × $\frac{34}{0.68}$ (ratio lead to silica) =	22.1 lb.
Lead in bullion = 4,720 lb. × 0.103 × 0.970 =	472 lb.
Lead accounted for =	537 lb.
Lead loss to stack = 562 lb. — 537 lb. =	25 lb.

The distribution of the lead is therefore

Product	Lead, lb.	Per Cent
Bullion	472	84.1
Matte	42.9	8.5
Slag	22.1	3.9
Dust, fume, etc.	25	4.5

CONCLUSION

The practising lead metallurgist, if he ever takes the time to look through these problems, will no doubt find much in them that is open to criticism. To all sins of omission or commission that may be thus disclosed the writer pleads guilty in advance. It is not with the intention of instructing the metallurgist in his business that these problems have been presented, but rather to fix in the mind of the student a few facts concerning charge calculations and the metallurgy of lead, which, without actual practice with numerical examples, he frequently fails to grasp.

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The Recovery of Benzol from Gas*

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One of the most noteworthy achievements in American chemical industry during these last two eventful years has been the rapid development of the recovery of benzol from coal gas. Associated principally with the manufacture of by-product coke, the business of recovering benzol in this country had previously lagged behind the parent industry which was already beginning to make striking progress three or four years before the outbreak of the great war. The lag was due, partly, to a seeming lack of real demand for the material; partly to the abundance of petroleum, and partly, also, to the groundless fear that the operations necessary for the recovery of benzol would add too many complications to the manufacture of by-product coke.

Thus, at the close of 1913 there were about sixteen plants in the United States making light oil from coke-oven gas. Most of the product from these plants was used for the enrichment of illuminating gas, leaving a comparatively small amount of material for other purposes. There were only two or three small plants for the manufacture of pure benzene, toluene, etc.

Even at that time, however, there were signs that the importance of the recovery of benzol was gaining recognition, and it is likely that the advancing price of gasolene would soon have led to a large extension of the industry even without the stimulus of war prices.

From the close of 1914 to the summer of 1915 the prices of benzol products rose with the cessation of foreign supply and the ever increasing necessities of the munition business, until pure benzene commanded over 80 cents per gallon and toluene was sold as high as $7.00 per gallon. The response was rapid. The first complete modern plant for the large-scale production of pure benzene and toluene was put into operation in May, 1915, and the total production of benzol products in the United States in that year rose to over twenty-two million gallons—more than twice as much as had been produced the previous year.

At present writing (January 1, 1917) there are about forty benzol recovery plants in operation in connection with by-product coke plants, having a capacity of approximately thirty million tons of coal per annum. Making due allowance for the facts that a number of these plants scrub only part of their gas and that part of the benzol is immediately used for enrichment, a conservative estimate would place the present annual light oil production at not less than forty million gallons. Three of these plants are now being enlarged, and eight new plants are in course of construction. The completion of this new work will bring the annual production of light oil up to nearly fifty million gallons.

The prices of benzene and toluene, although lower than the abnormal figures of two years ago, are still firm, the former at about 55 cents per gallon and the latter at about $1.75 to $2.50 per gallon.

It is to be especially noted that the increase of output has been almost altogether in the production of pure products; the amount of unrefined benzol now being made is probably actually less than was made in 1914. It appears probable that at least 80% of the present production is redistilled for the preparation of pure benzene and toluene.

USES OF BENZOL

The question is frequently asked: "What will become of this vast production of benzol after the war?" It must be remembered, in the first place, that the use of the benzol group of explosives, particularly trinitrotoluol and tetranitroaniline, is by no means confined to military purposes, and their consumption for commercial blasting operations will doubtless increase to a very large extent, because the war has given such a convincing demonstration of their superior qualities. The demand for military explosives is likely to continue on a considerably greater scale than before the war on account of the increased amount of military training that is being required in every country, and on account of the general recognition of the wisdom of accumulating and storing large reserve supplies of the principal explosives. It is one of the peculiar merits of trinitrotoluol that it can be stored indefinitely without risk of deterioration, and the importance of conserving this valuable asset in national defense cannot be overestimated.

The vast development of American chemical industries insures a market for large quantities of benzol products to be used for synthetic purposes. Benzene, itself, is an indispensable source of nitrobenzene and aniline with its long series of valuable derivatives. The manufacture of synthetic phenol, which is far outstripping that of carbolic acid made directly from coal tar, may be considered as a very important outlet for pure benzene on account of the great increase in the production of the various condensation products of phenol and formaldehyde. From toluene we obtain such well

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known products as benzaldehyde, saccharin and benzoic acid. Metaxylene is the source of a rather important series of dyes. The study of the other materials contained in smaller amounts in coke oven benzol and available for the production of many interesting series of synthetic chemicals has barely begun, but promises to afford striking results in the not far distant future.

Passing thus briefly over the consumption of benzol in the chemical industries, let us consider its employment as motor fuel. So far as bulk is concerned this bids fair to surpass any other possible source of demand. Previous to the war, Germany used over 50% of its benzol production for the operation of internal combustion engines. J. S. Critchley, president of the British Institution of Automobile Engineers, is quoted as stating that the carburetion of benzol presents no difficulties and that in actual practice the material gives an increase of mileage of about 20% over gasolene, affording at the same time 12 to 15 per cent more power. A series of tests made in 1913 at Brooklands, England (*Gas World*, Sept. 6, 1913, Coking and By-Product Section, page 9), showed an average of five miles increase per gallon.

The demands of the automobile industry alone are so great as to preclude the possibility of any destructive competition between benzol and gasolene. As was stated early in this paper the benzol recovery plants now in course of construction, together with those already operating, will make an annual production of about fifty million gallons of benzol. There are now over two million automobiles in operation in this country so that the contemplated benzol production would give each machine about 25 gallons. If all the coke that the country now requires were coked in by-product ovens with benzol recovery apparatus we should expect a total annual benzol production of about 110 million gallons or 55 gallons per machine. This total benzol production would be less than half the amount of gasoline and naphtha exported in 1915.

Other uses of benzol may be rapidly summarized for sake of completeness. Quantities are employed in the manufacture of paints, stains, varnishes and lacquers; in the cleaning industry; in the extraction of grease and fats; as solvents for rubber and for the manufacture of artificial leather and insulating materials. Lastly may be mentioned one use which should be considered rather as an economic waste than of benefit to the industry. This is for enriching illuminating gas to make it conform with antiquated candle power standards based on the use of flat flame burners. The utilization of mantle burners and the increasing tendency to replace old candle power specification by calorific standards, already universally adopted in more advanced European practice, will doubtless soon do away with the necessity for gas enrichment, and make it possible for large illuminating gas plants to recover their benzol and utilize it for more rational purposes.

PRINCIPAL OF BENZOL RECOVERY PROCESS

Before proceeding with the technical description of the benzol recovery process it may be well to give a few moments' consideration to the gas from which the material is extracted. The gases produced by the high-temperature distillation of coal are extremely complex in composition, but we may consider their constituents as grouped in two classes, viz., easily condensable and difficultly condensable substances, the former solid liquid or very soluble in water at ordinary temperatures, the latter gaseous and difficult to liquefy. Most of the substances of the first group such as water, ammonia, and the heavy hydrocarbons of tar, are removed by the usual operations of condensation and treatment with fresh water or acid. The amount and nature of the easily condensable substances left in the gas after undergoing these operations depends upon the vapor tension of each. Substances of a relatively high vapor tension such as benzene and toluene remain, to a large extent, uncondensed. Only 5% of the total benzol in the gas is removed with the tar in the condensing plant. Actually, of course, the gas after leaving the plant, contains slight amounts in the form of vapor, of all the original condensable substances, but the quantities of substances having higher boiling points than that of naphthalene (218° C.) are practically negligible.

Exclusive of water, the easily condensable vapors remaining in ordinary coke oven gas after the usual process of condensation and ammonia recovery, amount to about 1% by volume of the gas. They might be removed by cooling the gas to a very low temperature and this was actually done on a large scale in Europe some years ago, but the method was handicapped by mechanical difficulties largely due to the separation of ice and has been altogether abandoned. The only practical alternative which can be employed to recover these vapors, without altering their chemical constitution, is to treat the gas with a medium in which the vapors are soluble and from which they may be recovered by simple distillation.

This is the principle of every benzol recovery process in operation at the present time. It appears to have been first employed in 1859 by Vogel, who washed coal gas with fatty oils for recovering the benzol. It is peculiar that Vogel had only the idea of enriching these oils so as to improve their quality for illuminating purposes. Various processes for extracting benzol based on this principle were later patented; but it was not until 1887 that it was put into successful commercial operation. This was done in Germany by F. Brunk, who is generally acknowledged as being the founder of the modern benzol recovery industry.

It is a peculiar circumstance that the condensable hydrocarbon vapors belong almost entirely to the aromatic series. Benzene together with its homologues, toluene and the xylenes constitutes over 85%. Other substances present in much smaller amounts are carbon disulphide, thiophene, pyridine, naphthalene, and various olefines of both cyclic and open chain structure. Members of the paraffin series of hydrocarbons are almost entirely absent. The mode of formation of these compounds in the destructive distillation of coal, the effect of various conditions of carbonization, such as temperature and rate of heating on the character and amounts of the various substances formed, and the variation in the quality and quantity of the products from different groups of coals, are subjects of extreme interest on which our conceptions are not yet by any means clearly defined. The most important generalization that we are able to make is that the maximum yields of benzene and toluene are obtained at moderate coking temperatures. Higher temperatures have a tendency to form more benzene apparently at the expense of the toluene and extremely high temperatures decrease the yields of both benzene and toluene.

The percentages of the more important constituents of typical coke oven light oil and the amounts usually produced per ton of coal 2000 lbs. are given herewith:

Table I—Average Composition of Coke Oven Light Oil

	Per Cent in Light Oil	Gallons per Ton Coal
Benzene	66	1.782
Toluene	15	0.405
Xylene	8	0.216
Other substances (principally hydrocarbons)	11	0.297
Total	100	2.700

For sake of convenience a table of the more important properties of some of the constituents of light oil is also inserted. In the preparation of this table the literature has been exhaustively investigated and every endeavor has been taken to present the data as accurately as possible.

TABLE II

Compiled by the Laboratory of the H. Koppers Company, Mellon Institute, Pittsburgh, Pa.

	Carbon Disulphide		Benzene		Toluene		M-Xylene		Naphthalene	
	Data	Ref.	Data	Ref.	Data	Ref.	Data	Ref.	Data	Ref.
Formula (Molecular)	CS_2		C_6H_6		C_7H_8		C_8H_{10}		$C_{10}H_8$	
Molecular Wt. (O = 16)	76.12	1	78.05	1	92.06	1	106.08	1	128.06	1
Lbs. per U. S. gal. (60°F)	10.57	2	7.36	3	7.27	8	7.26	8	9.60	5
Sp. Gr. (0°C/4°C)	1.2921	2	0.8999	3	0.8845	4	0.8823	8	....	11
Sp. Gr. (10°C/4°C)	1.2773	2	0.8893	3	0.8757	8	0.8738	8	....	11
Sp. Gr. (15°C/4°C)	1.2698	2	0.8839	3	0.8714	8	0.8697	8	1.1517	5
Sp. Gr. (20°C/4°C)	1.2623	2	0.8786	3	0.8659	3	0.8655	6	....	11
Sp. Gr. (30°C/4°C)	1.2473	2	0.8679	3	0.8573	8	0.8574	8	....	11
Expansion Coefficient (0°C)	0.00125	2	0.0012	7	0.0010	7	0.00095	7	....	11
Boiling Pt. (750 mm Hg)	46.2	1	80.36	12	110.3	13	139.1	13	217.7	1
Increase in B.P. (°/mm Hg)	0.041	14	0.043	15	0.047	15	0.052	15	0.059	16
Vapor Pressure mm Hg (0°C)	127.9	14	26.63	18	7.20	18	1.75	18	0.022	9
Vapor Pressure mm Hg (10°C)	198.5	14	45.68	18	13.02	18	3.45	18	0.047	9
Vapor Pressure mm Hg (15°C)	244.1	14	58.90	18	17.22	18	4.74	18	0.062	9
Vapor Pressure mm Hg (20°C)	298.0	14	75.21	18	22.53	18	6.43	18	0.080	9
Vapor Pressure mm Hg (30°C)	434.6	14	119.34	18	37.45	18	11.43	18	0.135	9
Lbs. per cu. ft. Vapor (60°F-30")	0.202	10	0.209	10	0.244	19	0.281	19	0.339	20
Kg. per cbm. Vapor (0°C-750 mm)	3.42	10	3.54	10	4.14	19	4.76	19	5.72	20
Heat Combustion (Net) 15°C = 760 mm Hg.										
Cal. per Kg. liquid	3,480	10	9,960	17	10,150	17	10,230	17	9,700	17
Cal. per Liter liquid	4,420	21	8,805	21	8,850	21	8,910	21	11,170	21
B.t.u. per lb. liquid	6,260	21	17,930	21	18,270	21	18,410	21	17,460	21
B.t.u. per U. S. gal. liquid	66,100	21	132,100	21	132,600	21	133,500	21	167,300	21
Cal. per cu. m. vapor	11,550	21	33,600	21	40,150	21	46,500	21	52,400	21
B.t.u. per cu. ft. vapor	1,300	21	3,780	21	4,500	21	5,210	21	5,910	21
Sp. Heat (Cal. per Kg.)	0.240	22	0.419	24	0.440	24	0.383	25	0.314	26
Heat Vaporization (Cal. per Kg.)	83.8	27	92.9	27	83.55	28	78.25	28	....	11
Solubility in Water (22°C)										
Gms. substance in 100 gm. H_2O	0.219	22	0.072	22	Insol.	1	Insol.	1	Insol.	1
Gms. H_2O in 100 gm. substance	0.765	22	0.241	22	Insol.	1	Insol.	1	Insol.	1
Melting Point (°C)	—108.6	1	+5.4	1	—92.4	1	—54.8	1	+80.0	1

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NOTE—References, are, in many cases, to the fundamental data from which constants were calculated, i.e., (2) refers to relative volume data. (10) was computed from vapor density, molecular heat, etc.

OPERATION OF A BENZOL RECOVERY PLANT

In discussing the operation of a benzol recovery plant of modern type I shall deal principally with the Koppers patented process, because I have made a rather special study of this process as being typical of modern practice. To the best of my knowledge all of the coke oven benzol plants now under construction in America, with possibly one or two exceptions, are of this type.

In America the wash oil generally used to absorb the benzol is a petroleum product usually known as straw oil, of which at least 90% should distil between 250 and 350° C. A good absorbent oil has a specific gravity of less than 0.88 at 15° C. and is readily fluid at 4° C. It contains no naphthalene or pitch and exerts a good solvent action on benzol. In best practice the amount of benzol absorbed (technically the "enrichment") is kept between 2 and 3% of the absorbing oil. Too high enrichment is likely to lead to loss of benzol and too low enrichment may involve needless consumption of absorbing oil. In European practice heavy tar oils used almost exclusively as absorbing and steam media and such materials may find increasing application in America. Such tar oils should contain less than 7% naphthalene and 90% of the material should distil between 200 and 300° C.

Fig. I shows a flow sheet of a benzol plant showing the principal features of operation. Let us follow first the course of the gas and then that of the oil. Previous to treatment with the absorbing oil, the gas should be cooled to a suitable temperature which may vary from plant to plant and depends principally upon such factors as its moisture and naphthalene content, temperature of the wash oil, and percent enrichment desired. This cooling is accomplished by means of the cooler (A), which is preferably of the direct contact type. The water not only acts as a cooling medium, but mechanically washes a large portion of the naphthalene out of the gas and carries it into the separating sump (B). The cool gas then passes into the benzol washers (C). These are tall scrubbing towers of the hurdle type, effecting a very intimate and prolonged contact between gas and oil. The debenzolized gas passes out of the last washer through the return main to its point of consumption.

The fresh wash oil is pumped from the circulating tank (D) over the scrubbers in an opposite direction to the flow of the gas, maintaining the counter-current principle that should be adopted in nearly all scrubbing operations and bringing the fresh washing medium into the scrubbing system at a point where the gas contains the least light oil vapors. The distribution of the wash oil over the tops of the scrubbers is a very important matter, and should be done as uniformly as possible. The enriched wash oil accumulates in tanks usually located underneath the scrubbers, and is pumped from these to the benzol recovery plant to be heated for the purpose of releasing its benzol constituents.

Part of this heating is accomplished in the Koppers System by the utilization of the heat in the hot debenzolized wash oil leaving the still. Two heat economizers are used in this system. The cold oil first enters the heat exchanger (E), where it is heated by benzol vapors and steam from the still (H), thence it is conducted to a second heat exchanger (F), where it receives additional heating by means of hot debenzolized wash oil leaving the still (H). It is then still further heated to the maximum temperature desired by means of live steam in a superheater (G), from which it passes into still (H), this still is composed of a series of superimposed sections or chambers as in common distillation practice. The heated oil flows down through these sections while steam is blown directly into the lowest section and travels in a direction opposite to that of the oil. The mixture of benzol and water vapor is partially rectified in the upper portion of the still, and then enters the heat exchanger (E) as mentioned be-

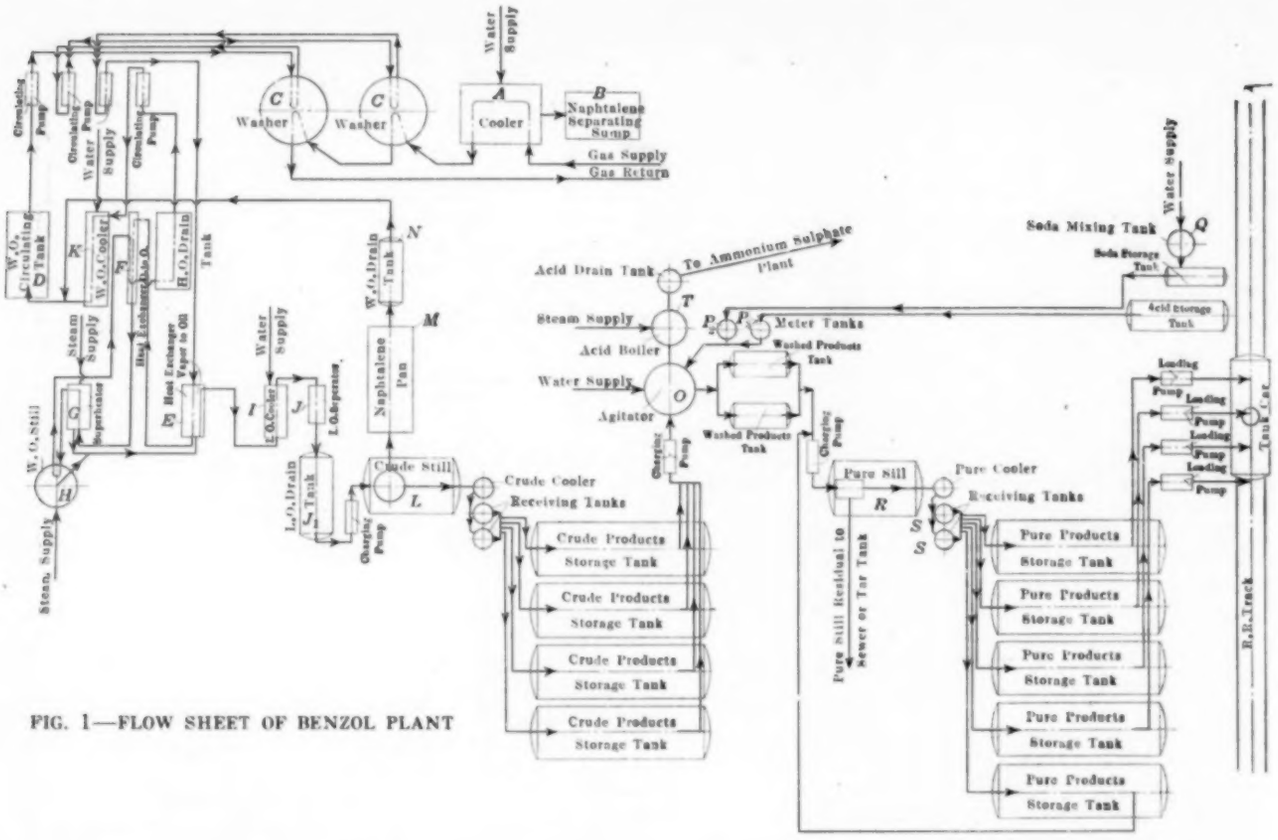

FIG. 1—FLOW SHEET OF BENZOL PLANT

fore, where it is condensed and the partial preheating of the enriched wash oil is effected. The remaining vapors are completely condensed and the total condensate cooled in a water cooled condenser (I). The light oil is separated from the water in the condensate by means of the separator (J).

The debenzolized wash oil after leaving the still passes through the heat exchanger (F), where it gives up a part of its heat to the enriched wash oil, as stated above. Then it is finally cooled in the water cooler (K). The cool oil is then delivered to circulating tank (D), thus completing the cycle.

FIG. 2—GAS COOLERS AND BENZOL SCRUBBERS

The improvements that have been made in recent practice have to do principally with effecting as great economy as possible of heat in the cycle of gas treatment, distillation and cooling through which the wash oil passes. In the Koppers system it is calculated that the devices for heat economy reduce the steam consumption in distilling the enriched wash oil by more than 80 per cent; 1000 gallons enriched oil 77 to 284 deg. F.; $(1000 \times 7.3 \times .537 \times 207) = 811{,}440$ B.t.u. = 840 lb. of steam at full pressure, or, per 1000 gal. purified benzols, $55 \times 840 = 46{,}200$ lb. of steam which, at 2 cents per 100 lb., costs $9.24; of this steam, heat exchanger (F) cooling the hot debenzolized oil from 275 deg. to 170 deg. F. in preheating the enriched oil, saves per 1000 gal. enriched oil (973 gal. debenzolized oil), $973 \times 7.3 \times .54 \times 105 = 402{,}675$ B.t.u. = 417 lb. of steam or 49.8 per cent of the total; heat exchanger (E) heating the cold, enriched oil by the benzol vapors and steam from the still, adds a recovery of about 256,000 B.t.u. per 1000 gal. wash oil, equivalent to 265 lb. of steam or 31.5 per cent of the total; in the two heat exchangers, therefore, the total saving is $417 + 265 = 682$ lb. of steam per 1000 gal. of enriched wash oil circulated, or 37,510 lb. of steam for every 1000 gal. of purified benzols produced, and the cost of steam for this purpose is reduced from $9.24 to $1.72 per 1000 gal. of product.

Further economy lies in the saving of cooling water circulation which would be required to cool the debenzolized wash oil.

The light oil is accumulated in a drain tank (J) shown in the lower part of the figure, and portions are taken for distillation in still (L). This still is usually known as the crude still, the first distillation of the wash oil being made for the purpose of effecting an approximate separation of several fractions of dif-

ferent boiling points preliminary to washing and final rectification. This and subsequent distillations are made intermittently in stills of large capacity (6000 to 12,000 gal.), which give better fractionations than are possible in smaller apparatus. The continuous type of stills has not been found satisfactory in this work. The crude still does not require the elaborate dephlegmator, that is necessary on the final rectifying stills. The heating is accomplished by means of internal steam coils and a direct steam spray. The benzol and toluol are principally distilled off by indirect heat, using the steam coils, and the higher boiling constituents xylol, solvent naphtha, etc., are then distilled over by introducing steam directly into the still.

After the benzol, toluol, xylol and solvent naphtha have distilled off, a certain amount of wash oil containing naphthalene remains in the still tank. The presence of wash oil in the light oil is due not only to mechanical trapping of the heavy oil during the distillation, but also to the actual distillation of some of its original constituents by agency of the direct steam used. The products recovered from 1000 gal. of light oil vary according to the kind of coal coked, the regulation of the ovens and the method of operation of the light oil plant. In one plant that may be taken as fairly typical of a well-operated system the yields average about as follows:

From 1000 gal. crude light oil.
680 gal. crude benzol.
140 gal. crude toluol.
50 gal. crude xylol.
55 gal. solvent-naphtha.
75 gal. wash oil residue with naphthalene.

The wash oil remaining in the still is drained into cooling pan (M), where it is cooled in the air to crystallize out the naphthalene. The wash oil is drained away from the latter into tank (N), and then is returned to the main circulating tank (D). In large plants where the amount of naphthalene is great, a centrifugal dryer is employed for the purpose of separating the small amount of oil remaining in the naphthalene, and also for reclaiming the naphthalene from the separating sump at the foot of the gas cooler. The crude naphthalene so obtained can be sold as such, or may be put into the tar in the coke plant.

The products obtained from the crude still will satisfy many commercial purposes in normal times. Moreover, at present the demands of chemical manufacturers for benzol and toluol of a high degree of purity have made it advisable to accomplish the complete process of purification at the coke plant to serve this important part of the trade. For this purification the crude benzols are first washed with sulphuric acid and then with caustic soda and water. This operation is accomplished in agitator (O), which is a large lead-lined vessel with an efficient mechanical mixing device for bringing the acid and benzol into intimate contact. The acid is commercial concentrated sulphuric acid (66 deg. Bé). The quantity used is accurately measured from the meter tank (p_1). The caustic soda solution is prepared in the tank (Q) and measured in the meter tank (p_2).

The acid has the effect of reacting with and to a large extent polymerizing most of the impurities which consist of various olefines and substances of similar character, together with certain phenoloid bodies. This results in the formation of resinous substances of very high boiling point, part of which are insoluble in the benzols and settle out with the acid in the bottom of the agitator, while part go into solution, giving the benzol a dark brown or a reddish color. The acid sludge is drawn off and treated, as will be described later. The caustic soda neutralizes any traces of acid which may remain in the agitator and effect the removal of some of the phenoloid bodies. After the soda wash the benzol is a lighter brown color, but always requires distillation. The washed benzol is delivered from the agitator to the still (R). This still is generally of the same capacity as the crude still, but is provided with a very efficient dephlegmator. Sometimes purified products of less exact boiling points are desired. In this case the washed benzols are distilled rapidly, simply to separate the benzol from the resinous materials in solution. The products so produced are termed "purified," *e.g.* 90 per cent purified benzol, 50 per cent pure benzol,

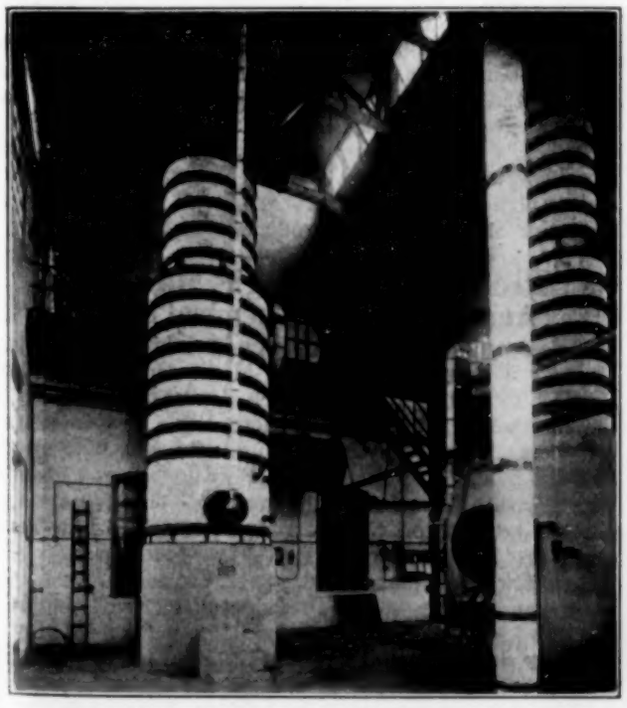

FIG. 3—BENZOL RECOVERY PLANT—WASH OIL STILL AND CRUDE STILLS

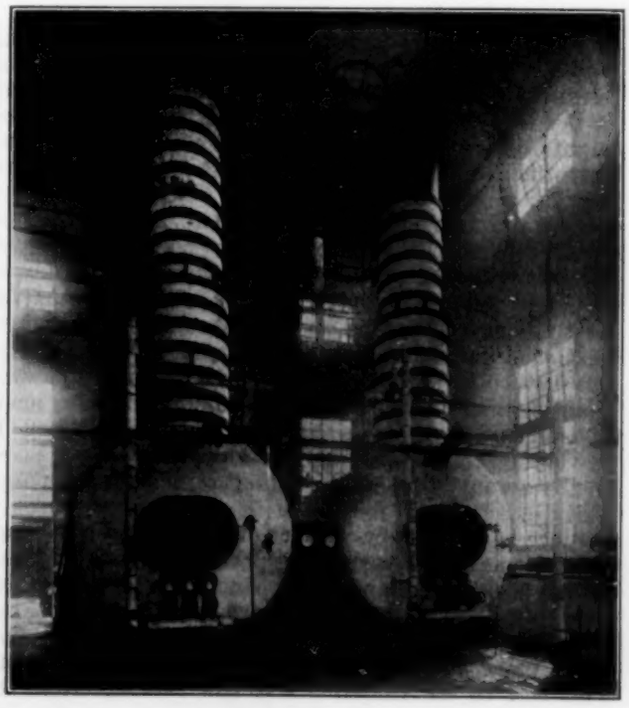

FIG. 4—BENZOL RECOVERY PLANT—CRUDE AND PURE STILL

etc., the nomenclature being based on the percentage in test distilling under 100 deg. C. The distillation for the preparation of pure products is conducted more slowly, the condensate being collected in receivers (S), and tested carefully before placing in the final storage tanks.

Great improvement has been made in recent practice in the distillation of pure benzol and toluol. In a well-designed plant the cuts are remarkably clean and the percentage of intermediate fractions small. At one benzol plant pure benzene is regularly being produced of a grade such that less than 5 per cent. distils below 80.1 deg. C. and 95 per cent distils within 0.3 deg. C. Pure toluene also is being made of which less than 5 per cent distils below 110.0 deg. C. and 95 per cent within 0.5 deg. C. This extraordinary degree of purity is of great advantage to manufacturers of explosives and synthetic chemicals requiring the use of pure benzols. The ease with which these distillations can be effected and the sharpness of the cuts obtained is very remarkable. Much of the secret of success lies in the correct design of the dephlegmator. The record of one plant shows the following average figures for the distillation of crude benzol containing toluene:

Pure benzene	85.3%
Intermediates	3.4%
Pure toluene	9.8%
Residue	1.3%
Loss	0.2%

The residue is often allowed to go to waste; but may be mixed with the coke-oven tar without injury.

The water and caustic soda used in the agitator are drained to the sewer. The acid sludge drained from the agitator is delivered to a boiler (T), in which it is treated with direct steam. This effects a separation of the resinous materials in the form of a heavy carbonaceous spongy deposit. An acid of about 40 deg. Bé is recovered and may be used on the coke plant for making ammonium sulphate. The boiler is covered during the operation of steaming and the escaping vapors are condensed in a cooler.

Regarding other details, such as the arrangement of pumps, storage tanks and piping, the diagram is self-explanatory.

The upkeep of a benzol plant costs remarkably little and the labor required in operation is small. A complete plant handling 5000 gal. of light oil per 24 hr. is operated by five men on day turn and three men on night turn, with two chemists for control testing and three laborers on day turn only for loading shipments and for general utility purposes.

The apparatus that is subjected to the most severe conditions is the superheaters. Spare superheaters should always be provided and the apparatus arranged so as to be readily interchanged. All apparatus for heating and cooling the wash oil should be so arranged that each individual unit can be taken out easily without disturbing the other apparatus. All apparatus with the exception of that exposed to sulphuric acid is made of iron and steel, no special alloys being required. It is very essential that the utmost precaution be taken in the arrangement of the piping to obviate the possibility of accidental mixing of the different products.

Since benzol is a by-product of coke and gas making, those items in the cost of its production which are involved also in coke and gas production, are not chargeable to the benzol. In other words, the cost of making coke-oven benzol includes only the cost of its extraction from the coke-oven gas, and that of its purification. This cost in the United States will vary according to local conditions, but usually lies between 4.0 and 7.0 cents per gallon.

At the close of the European war, when prices again become normal, it will be possible with the large plant capacity then available to make a substantial profit from the production and sale of automobile benzol (90 per cent purified) at prices competing with those of gasolene. There are other large uses creating a demand for the various benzols, described in earlier paragraphs and further uses will be developed as the supply of the material becomes greater.

The effect of the removal of benzol on the calorific value of the gas has been well worked out by J. W. Shaeffer, who recently published his results in an article read before the October, 1916, meeting of the American Gas Institute. The actual loss in the calorific value of the gas amounts to about 5.8 per cent, which is a figure representing the average practice of about thirty by-product coke plants. The figure agrees well with theoretical considerations. The result is that more debenzolized gas has to be used for accomplishing a given heating effect. Assuming that one ton of coal makes 11,000 cu. ft. of gas, a reduction of 5.8 per cent is equivalent to 638 cu. ft. less gas. As boiler fuel this gas is worth about 6 cents per 1000 cu. ft., so that the reduction may be figured to cost about 3.83 cents per ton of coal, i.e. about 8 per cent of the normal value (based on gasolene prices) of the total benzol recovered.

H. Koppers Company Laboratory, Mellon Institute, Pittsburgh, Pa.

Chemical and Electrical Porcelain

Joint Meeting of American Electrochemical Society, American Chemical Society, and Society of Chemical Industry

Authorities on the subject of ceramics will talk on the manufacture of "chemical and electrical porcelain" in the United States at a joint meeting of the American Electrochemical Society, American Chemical Society and Society of Chemical Industry to be held at the Chemists' Club, on Friday evening, February 9. The speakers will be L. E. Barringer, of the General Electric Company, president of the American Ceramic Society; A. V. Bleininger, of the Bureau of Standards, Pittsburgh; and Charles F. Binns, director of the New York State School of Clay Working and Ceramics, Alfred, N. Y.

The development of the manufacture of porcelain in the United States since the war has been very rapid. Before the war all of the better grades of porcelain and ceramics were imported, but this country is now making products which compare very favorably with those products formerly imported. In the manufacture of electrical porcelain this country excels all other countries. Samples of some recent products will be shown.

Detroit and Pittsburgh Meetings of American Electrochemical Society

The spring meeting of the American Electrochemical Society will be held at Detroit, Mich., from Wednesday, May 2, to Saturday, May 5, inclusive. On May 2, visits to automobile plants will be made, with a "get-together" roadhouse dinner in the evening. On May 3, sessions will be held for Electric Steel, Ferroalloys, and general papers, with a smoker in the evening. On May 4, there will be sessions on Non-Ferrous Metals, and Low-Temperature Electrochemical Processes, followed by visits to electric steel plants and power houses in the afternoon, and addresses by President FitzGerald and Mr. Alexander Dow in the evening. The session of May 5 will be devoted to electrodeposition of metals, theory and prevention of rusting of iron.

The fall meeting will be held in Pittsburgh, from Wednesday, October 3, to Saturday, October 6, inclusive.

Presentation of the Perkin Medal to Ernst Twitchell

On Friday evening, Jan. 19, in Rumford Hall, Chemists' Club, before a splendid gathering and amid suitable patriotic decorations, the Perkin Medal for this year was formally presented to Dr. Ernst Twitchell for his work on the hydrolysis of fats, in a meeting of the New York Section of the Society of Chemical Industry, held jointly with the Sections of the American Chemical Society and the American Electrochemical Society.

Dr. JEROME ALEXANDER, chairman of the New York Section of the Society of Chemical Industry, presided. He first made the announcement that Dr. Parker C. McIlhiney, secretary of the New York Section for many years, had resigned and that Dr. Allen H. Rogers had been appointed to fill his place. A rising vote of thanks was tendered to Dr. McIlhiney for his long and efficient service as secretary of the New York Section.

In coming to the subject of the evening, Dr. Alexander gave a brief review of past Perkin medal awards and of notable discoveries in general in America. He said America has contributed more than her share of the notable discoveries of the world and not a few of these have been in the field of chemistry. In introducing DR. CHAS. F. CHANDLER, the presentation speaker, as the "dean of the chemical profession in America," he took occasion to congratulate him on the celebration of his eightieth birthday.

ERNST TWITCHELL

Dr. Chandler then delivered his presentation address, which is printed in full below, reviewing briefly the state of the art prior to Dr. Twitchell's work and giving a résumé of his work. He then presented to Dr. Twitchell the medal, with a few felicitous remarks "as a token of the esteem and affection of his fellow chemists."

Dr. TWITCHELL accepted the medal with a few words of thanks for the appreciation of his work, and followed with a history of his discoveries in the hydrolysis of fats. He was followed by Dr. A. C. LANGMUIR of Marx & Rawolle, Brooklyn, N. Y., who told about the Twitchell process in the glycerin trade, by Dr. MARTIN H. ITTNER of Colgate & Co., Jersey City, N. J., who spoke on the Twitchell process in the soap and candle industry, and by Mr. HERMAN B. SCHMIDT, who concluded the program with some interesting personal reminiscences.

The evening was very enjoyable. The speeches were brief and to the point. Their full text follows:

Presentation Address

By C. F. Chandler

It is my privilege and very pleasant duty as Senior Past President of the Society of Chemical Industry, residing in this country, to present to Ernst Twitchell, B.S. and D.Sc., the eleventh impression of the Perkin Medal, in recognition of his most original and valuable work in Applied Chemistry.

Dr. Twitchell was born in Cincinnati, on February 26, 1863. He graduated in 1886 from the University of Cincinnati with the degree of B.S., and in 1915 received from his alma mater the honorary degree of Doctor of Science. On his graduation in 1886, he was appointed chemist to the Emery Candle Company of Cincinnati, and has been connected with that firm ever since. At present he is chemical director to the Emery Candle Company, president of the American Oil Treating & Hardening Company, and chairman of the Board of Directors of the Twitchell Process Company.

Dr. Twitchell has devoted the past thirty years chiefly to the chemistry of fats. His investigations and discoveries have been given to the chemical world in the form of articles in various chemical journals and in letters patent of the United States and other countries.

In 1891 he published his method for the determination of rosin in the fatty acids of soap. The method is based on the fact, observed by him, that the fatty acids when dissolved in absolute alcohol, are readily and completely converted into ethyl ethers, by the action of dry hydrochloric acid gas which, absorbing the water set free, acts to induce the reaction. On the other hand the rosin acids under the same treatment remain unchanged, and may be determined volumetrically with standard soda solution, or gravimetrically. Lewkowitsch, in his comprehensive work on "Oils, Fats and Waxes," remarks: "Of all the methods for determining rosin acids in the presence of fatty acids, the Twitchell method gives the best results."

Dr. Twitchell's most important contribution to industrial chemistry involves new and improved methods for the hydrolysis of oils and fats for the production of the free fatty acids and glycerin. These methods have very largely superseded the old methods such as that of Chevreul & Gay Lussac (in 1825), who saponified in open kettles with alkali. This process was improved by Milly in 1881, who substituted milk of lime for alkali, and later by conducting the saponification in closed vessels, under pressure, reduced the amount of lime required from 14 per cent of the fat to as low as 2 per cent. Then came the process of Dubrunfant first applied practically in 1842 by Jones and Wilson, in which the fat was saponified by sulphuric acid, and the fatty acids subjected to distillation.

Wilson and Gwynne later applied the discoveries of Bertholet and Melsens in a process in which the fat was decomposed by superheated steam and subsequent distillation, which was practiced at the works of Prices Candle Company, Battersea. Finally in 1854, Tilghmann introduced his process in which the fat, emulsified in water, was forced through a coil at a temperature of 320 deg. C. Marix found that by adding a little calcium or magnesium carbonate to the water, the temperature and pressure could be very materially reduced to as low even as 3 to 5 atmospheres.

The art of saponifying the fats had reached this stage of development when Dr. Twitchell made an entirely new departure by the application of new reagents, which by acting as catalysers, even when used in such small proportions as 1 to 2 per cent, are able to completely saponify the fats. The operation may be conducted by simply boiling the fat with water and the proper quantity of the "saponifyer." The agents first employed by Dr. Twitchell were the sulfo-acids of the fatty acids, such as sulfo-stearic acid, sulfo-oleic acid, etc. Later

Dr. Twitchell found that by introducing an aromatic radical into the sulfo-acid, a much more satisfactory catalyzer was obtained; a sulfo-fatty aromatic acid. Such aromatic radicals as are furnished by benzene, phenol, and naphthalene are employed; naphthalene stearosulfonic acid being a favorite catalyzer.

These acids when converted into salts of such metals as barium, calcium, magnesium, aluminium, etc., can be produced as stable dry powders, to be used with a suitable proportion of sulphuric acid, or hydrochloric acid to make them active.

The Twitchell process has made possible the large scale saponification of fats for the production of crude glycerin free from salt and of fatty acids for direct combination with soda as to make soap instead of using the more expensive caustic lye on the neutral fat.

Low-grade fats, such as garbage grease, cottonseed oil foots, etc., were formerly with difficulty used in the soap or candle industry. Such materials can now be readily worked up by the Twitchell process, the fatty acids being distilled to remove color before use. This releases a large quantity of the higher grade fats for use as food products.

The bulk of the soap used in Belgium, Holland, Germany and Scandinavia is said to be prepared from fatty acids direct, and 75 per cent of these acids are made by the Twitchell method. Millions of pounds of fat are saponified yearly in the United States by this process, and practically all of the larger soap factories have Twitchell plants.

All of the recent books in German and English on the soap and fat industries discuss the Twitchell process in full.

Address of Acceptance of Perkin Medal

By Ernst Twitchell

The first suggestion which lead to my discovery of a special catalyser for hydrolysing fats came to me in studying the so-called "acidification process." This was one of the oldest methods used in candle factories for separating glycerol from fatty acids. It consisted in treating the fat at a fairly high temperature, over 100 deg. C., with a small amount of concentrated sulphuric acid, 4 per cent or considerably less could be used; the product was then boiled with an excess of water. The result is a layer of fatty acids floating on the acid water containing the glycerol.

This reaction could not be explained by the assumption that there is a combination of sulphuric acid with the fat or fatty acid and glycerol, which decomposes during the subsequent operation of boiling with water, because there was not enough sulphuric acid to combine with all of the fat. Various theories have been given to explain the acidification process, some quite absurd. For instance, in one text-book it is stated that fats consist of minute globules surrounded by membranes and that the function of the sulphuric acid is simply to char and destroy these membranes, leaving the fat in a condition to by hydrolysed by water at 100 deg. Another theory was frequently seen even in recent articles; it stated that compounds are formed which cause the fat to emulsify with water, and the idea evidently is that if a good enough emulsion is obtained, hydrolysis will take place even at 100 deg. I have seen this theory given to account for the action of my hydrolysing reagent. As a matter of fact, fats do not hydrolyse at 100 deg., practically speaking, with water alone, even though they may be perfectly emulsified. At higher temperatures than 100 deg., and under pressure, hydrolysis takes place, as is illustrated in the autoclave process of separating glycerine.

In the course of practical experiments with the acidification process I found that I could reduce the amount of sulphuric acid used very considerably and yet obtain complete decomposition; but often the boiling with water had to be decidedly prolonged. It seemed clear that there was some catalytic agent which caused the reaction between the fat and the water in this process of boiling, and it would naturally occur to any one that this catalyser was probably some sulphur compound produced by the action of sulphuric acid on fat. I found that compounds of this nature could be roughly separated from the fat which contained them by treating with petroleum ether in which they were insoluble. They could be further purified by solution in ether and extraction with water and were easily identified as sulphonic acids by their acidity, the formation of potassium sulphate on fusion with caustic potash, and other characteristics.

It occurred to me to prepare this catalyser outside of the body of the fat, thus avoiding the action of the sulphuric acid in forming with the fat undesirable compounds, in charring, discoloring, and partially destroying it.

As these sulphonic acids were probably produced by the action of the sulphuric acid on the oleic acid constituent of the fat, I first studied the results of the action of sulphuric acid on pure oleic acid under various conditions of temperature, quantity, etc.

The action of sulphuric acid on oleic acid at low temperatures, as was known, produces a compound of sulphuric acid, stearo-sulphuric acid, an acid sulphuric ester. This was not the catalyst that I was seeking. It very probably has all the properties of a catalyst for the hydrolysis of fats except one; it is decomposed on boiling with water, and as the hydrolysis of a fat hardly takes place at all under any circumstances at a temperature lower than 100 deg., it is plain that this compound would not serve my purpose.

The compounds obtained on treating oleic acid with sulphuric acid at a temperature of 100 deg. or over are not sulphuric acid compounds, but are true sulphonic acids. The principal one seemed to be derived from two molecules of oleic acid and contained one sulphonic acid group and one carboxyl group.

I have never seen this sulphonic acid described, but believe that I had in my hands a fairly pure compound of the composition $C_{17}H_{34}(SO_3H)$ COO. $C_{17}H_{34}COOH$. This was my first hydrolysing reagent or saponifier. But as it was difficult to prepare commercially in fair yield and of any degree of purity, I dropped further investigation along this line on the accidental discovery of the fatty aromatic sulphonic acids, described in the *Journal* of the American Chemical Society of January, 1900.

In this research the most important question was: "What properties must a substance have to act as a catalyser to accelerate the hydrolysis of fats?" My views on this subject I have partially expressed in my paper, "A Reagent in the Chemistry of Fats," published in the *Journal* of the American Chemical Society of February, 1906, where I say that it must be a strong acid, one dissociated strongly in water giving a considerable concentration of hydrogen ions; and then it must be soluble in both fat and water and cause the one to dissolve in the other.

The only bodies that I can at present conceive to have the desired properties are sulphonic acids containing higher fatty radicals. They have the physical character of fats or oils, yet are soluble in water forming soapy solutions, and are strong acids.

As I have said, the discovery of the fatty aromatic sulphonic acids was made by accident. I had a mixture of oleic acid and benzine, which I treated with an excess of sulphuric acid and then poured the mass

into water. I was not surprised to find an oily layer floating on the acid water, and when I found this oil to be soluble in pure water, that also did not surprise me, as I supposed I had simply stearo-sulphuric acid; but when I found that, after boiling, it still remained soluble, I felt sure that I had a sulphonic acid, and the analysis of the product confirmed my conclusion. This is the compound which has been put to practical use in the separation of glycerol and fatty acids. Instead of benzine, naphthalene is used with oleic acid in the manufacture of the commercial article. This "saponifier," when added in the proportion of half a per cent or less to fat boiling with water in an open tank, will cause the separation of the glycerol.

Besides the compound containing two stearic radicals and a sulphonic group, the first which I found to have the catalytic property, and the fatty aromatic sulphonic acids, I have also prepared hydrolysing reagents by treating oleic acid at 200 deg. to 220 deg. C. with sulphur, or in the cold with sulphur chloride (S_2Cl_2), and when oxidizing with nitric acid, potassium permanganate, bromine, or other oxidizing agent. The resulting compound contained one sulphonic and one carboxyl group and its molecular weight and other properties showed it to be a sulphonic acid of the stearic radical.

Belonging to this class of substances is a compound, cetyl sulphonic acid, described by A. Reychler two or three years ago. When I saw this description I was sure that it was also a catalyser of the same type as my reagent, although Reychler does not mention this as one of its properties.

As this is a typical compound, it may be interesting to describe how it was prepared, partly following directions given in Reychler's paper. Cetyl alcohol, prepared by saponifying spermaceti with caustic potash and extracting the soap with petroleum ether, was converted into the iodide by dropping iodine into a heated mixture of the alcohol and red phosphorus. This iodide, after purification, was converted into the sulphhydrate by treating with alcoholic KHS and the cetyl sulphhydrate converted into cetyl sulphonic acid by oxidizing with potassium permanganate, the excess of which was reduced with sodium sulphite. The cetyl sulphonates could be freed from most of the foreign matter by taking up with hot water from which sodium cetyl sulphonate crystallized on cooling. This was dried, extracted with petroleum ether, then dissolved in water and treated with hydrochloric acid. The salted out cetyl sulphonic acid was dissolved in ether and remained in a nearly pure state as a residue on evaporating the ether. It can be further purified by crystallizing its sodium salt from dilute alcohol and there can be no doubt of its composition. It is a simple sulphonic acid of a hydrocarbon of the paraffine series.

Reychler explains some peculiar properties of this compound in this way: The sulphonic radical tends to make it very soluble in water, while the long hydrocarbon chain has just the reverse effect. The result is that it forms colloidal solutions. Fahrion, in reviewing Reychler's article, calls the cetyl sulphonic acid, "Reychler's hydrogen soap," and that term, *hydrogen soap*, is as good a definition as I can think of to cover the whole group of compounds which catalytically induce hydrolysis of fats on the principle of my discovery. An alkaline soap plus hydrogen ions would no doubt have the same effect if it were possible to have such a combination. Besides its use in hydrolysing fats, my catalytic agent has been applied to other less important ones. A catalyst which would accelerate the hydrolysis of an ester in the presence of an excess of water would also accelerate the esterification of a fatty acid and an alcohol on the removal of the water formed. Fatty acids can be made to combine with glycerol and other alcohols of high boiling point by simply treating a mixture of the two with a small quantity of the reagent and evaporating the water formed at 100 deg. C.

The solubility of sulpho-fatty acids in both fat and water leads to a method of separating solid and liquid fatty acids of which I have made some application. If a small quantity of the sulphonic reagent is dissolved in melted mixed fatty acids and the mixture allowed to cool, the solid acids will crystallize out pure and the liquid acids will contain the sulpho-fatty acids, being thus rendered slightly soluble in water, and on treating with water can be washed out from the mixture, partly in solution but mainly as an emulsion.

Patents have recently been obtained by Grigor Petroff of Russia on a reagent obtained as a by-product in refining petroleum with fuming sulphuric acid. This is a sulphonic acid of hydrocarbon radicals, probably both of the paraffine series. It is a very efficient catalyser in the hydrolysis of fats, for which purpose it is now largely used.

The Twitchell Process and the Glycerine Trade

By A. C. Langmuir

Some years ago a manufacturer asked my assistance in developing a chemical process. He wanted a process which would "cost nothing to work, would take nothing out of the product and would put nothing in." This man had heard nothing of catalytic methods, but his conception of the ideal chemical process which he was requiring corresponded closely to the modern catalytic methods such as the platinum contact process for the manufacture of sulphuric acid, which costs nothing to operate, once the contact mass is prepared, and which brings about the combination of sulphur dioxide and oxygen without adding an impurity which must be subsequently taken out or removing something which would lower the yield.

The Twitchell catalytic process goes far toward meeting this idea in the saponification or breaking up of fats and oil into their constituents, glycerine and fatty acids. Twitchell's invention (Patent 601,603, July 17, 1897) was made at a time when catalysis was not the universal subject of attention it is to-day. The Badische process for the catalytic production of sulphuric acid had not been published, and catalysis was a new thing in chemical industry.

Twitchell's work has been characterized by a sound appreciation of the work of physical and organic chemists and his analytical and technical methods have been worked out, not empirically, but from theoretical premises. Thus the Twitchell method for the determinatin of rosin in mixtures with fatty acids, as in soap analysis, rests upon the principle of the esterification of the fatty acids when treated with hydrochloric acid gas in presence of absolute alcohol and his discovery that resin acids when so treated refused to combine with the alcohol and could subsequently be separated as pure rosin. Although published in 1891, this method stands to-day as the most accurate process for the determination of rosin in presence of fatty acids.

Again in 1897 we find him bringing out a method for the separation of saturated and unsaturated fatty acids based upon the solubility of fatty acids with double bonds, such as oleic acid, in concentrated sulphuric acid at ordinary temperatures with the formation of sulfo-fatty acids soluble in water. The saturated fatty acids such as stearic acid are unacted on. In 1914 Twitchell makes uses of the principle of the equal depression of the freezing point for equal molecular proportions and determines the composition of mixtures of fatty acids

by the observation of the freezing point in the Beckmann apparatus. To test whether a given sample of fatty acid is identical with a fatty acid of known character he adopts the novel plan of adding a portion of the known acid and noting whether there is any change in the melting point of the mixture.

Possibly his investigation of the action of concentrated sulphuric acid on fatty acids led to his discovery of the catalytic action of these sulfo-fatty acids in bringing about the decomposition of fats by water, as little as 0.5 per cent splitting up the fats almost completely on digestion with water.

The prevailing method for the manufacture of soap consists in the saponification of the fat by boiling with caustic soda lye. The fatty acids combine with the soda as soap, which is separated by the addition of salt and comes to the surface in the molten condition. The glycerine is set free and remains dissolved in the spent lye. It is contaminated by the presence of salt used to render the soap insoluble. During the concentration of the spent lye for the recovery of the glycerine a large quantity of salt is thrown out, making the evaporation somewhat difficult, although this difficulty has been largely eliminated of late years by the use of properly designed evaporators working in vacuo. The final crude glycerine is a saturated solution of sodium chloride and some sulphate together with sodium salts of the lower fatty acids, in glycerine and water. The glycerine averages about 80 per cent and contains about 10 per cent mineral salts.

The glycerine refiner distills this crude soap lye glycerine with superheated steam in vacuo for the production of dynamite glycerine and chemically pure. The presence of so large a quantity of salt raises the boiling point of the glycerine and reduces its vapor tension so that the output is reduced. Furthermore, the salt accumulates in the still, producing finally a semi-solid mass of salt and glycerine, together with tarry matter which constitutes the "foots" of the glycerine trade. It is a difficult matter to extract all the glycerine from this residue without undue loss. The treatment of the "foots" is one of the problems of the glycerine trade.

The glycerine distiller, therefore, prefers a crude glycerine which is free from this large admixture of salt. Up to the early nineties all the crude glycerine refined consisted of what is termined saponification or candle crude. It was the by-product of the candle factory and was produced by the breaking up of fat in autoclaves by heating under pressures of 200 lb. and more with water and a little lime. The fat was split into fatty acids and glycerine directly and the latter was a product of considerable purity, containing about 88 per cent glycerine and less than 1.0 per cent of mineral matter. With the greatly increased demand for glycerine for explosives the soap makers, who formerly discarded their spent lyes, found it profitable to work them up, and to-day scarcely a soap plant can be found that does not recover its glycerine as a by-product. This change in the business compelled refiners to develop methods for distilling soap lye crude glycerine and eventually the larger refiners were working mainly on soap lye rather than candle crude, although there were still a number of glycerine refiners who worked exclusively on candle crudes. Saponification crudes free from salt have always been in greater demand and have commanded a higher price per unit of glycerine. For several years before the advent of the Twitchell process it looked as if saponification glycerine would practically disappear as a raw material in glycerine refining, but with the success of this process the Twitchell saponification crudes made their appearance and are now a factor of very considerable importance.

The ideal of the glycerine refiner has thus been the production of a saponification rather than a soap lye crude by the soap manufacturer. It has also been the hope of the soap trade to obtain directly by the deglycerinizing of the fat a relatively pure glycerine as a byproduct and free fatty acids which could be combined with the cheap alkali, carbonate of soda, to make soap instead of the relatively expensive caustic soda. To meet this need have been developed the Twitchell process, the Krebitz lime saponification method and the Connstein ferment process.

The Twitchell process is characterized by its simplicity, and the low cost of the plant. Prior to Twitchell's discovery free fatty acids could only be obtained by the autoclave process involving a heavy capital outlay for copper apparatus which could only be used in small units and at a high temperature and pressure, making the operation expensive and somewhat dangerous. The autoclave saponification was used only in the preparation of fatty acids for candle manufacture, as the process was too costly to be used in the production of fatty acids to be used in soap. The Twitchell process is effected in loosely closed wooden tanks by digestion with water and as little as 0.5 per cent of the reagent and at a temperature not exceeding that of exhaust steam. The reaction may be carried out on a scale limited only by the size of the tank. The Twitchell process has made possible the saponification of fats on a huge scale for the direct production of free fatty acids and saponification glycerine. When combined with the distillation of the fatty acids for the improvement of their purity and color it has opened up for the soap trade the use of low-grade fats such as garbage grease and cotton seed oil foots, the distilled fatty acids being combined directly with carbonate of soda to produce light-colored soaps, and the glycerine being made available for the manufacture of dynamite glycerine. In this way the Twitchell process has benefitted the glycerine trade in these days of glycerine scarcity by opening up new sources of supply, which were previously unavailable.

In Germany, Austria, Belgium, Holland and Scandinavia the larger soap plants prepare soap from fatty acids directly, and it is stated that in most of them the Twitchell process is used for the saponification of the fats.

The crude glycerine prepared by the Twitchell process comes to us from all parts of the world in normal times. There is no evidence that it is any less pure than the saponification glycerines prepared by other processes provided the fat used as a raw material is reasonably pure. Of course, a crude glycerine manufactured from a low-grade fat will fall behind a crude made from good tallow, but this is the fault of the fat and not the Twitchell process.

The Twitchell Process in the Soap and Candle Industry

By Martin Hill Ittner

It is essential in the candle industry to have a satisfactory method for separating the fatty acids, as such, from fats and oils. In the soap industry such a method, although it may be considered highly desirable, is not absolutely essential, since very satisfactory methods of direct saponification by alkali with the formation of soaps have long been utilized.

In recent years there has been an ever increasing demand for fats and oils and for glycerine, resulting in greatly increased market prices for these articles. The

market for soap and candle materials is directly related to the market for fats and oils for edible purposes, and an increased demand from either source usually results in higher prices for all fatty materials. High costs of fatty materials have made the practice of economy in the soap business essential. This economy may manifest itself in several ways. We will assume at the outset that the soap manufacturer wishes to maintain the quality of his products and therefore does not wish to make any sacrifice in this direction. His economy must therefore direct itself in one of the following directions: He must be able to utilize the fats and oils which give the greatest soap-making value at the lowest cost per unit, whether these materials are of the better or of the poorer grades, and he must so utilize his raw material that his final product will be of the same high quality no matter which grade is used. This means that he must have a method for getting good results out of poor material when poor material gives him the greatest value. It is also essential that he have some method whereby he may realize the maximum yield of glycerine at a low expense for recovery. This will readily be understood when I explain that at present market prices for fats and glycerine, which are both abnormally high, the value of the glycerine which can be obtained from one pound of neutral fat is about one-third of the cost of the fat. Another possible way of economizing is by quicker and easier methods of manufacture.

All of these advantages have been realized in some degree by the advent of the Twitchell process. This process has given a quick and easy method of obtaining fatty acids and glycerine from the better grades of fats so that the fatty acids are at once ready for making into better grades of soap, and the glycerine is in a condition suitable for easy refining. With care of operation the yield of glycerine may be made to approximate closely to that theoretically obtainable. When one operates on fats of poorer quality, and this may include black greases, the Twitchell process furnishes a most satisfactory method for saponifying. It renders the glycerine available even from such material and gives acids in good condition for refining by means of distillation. Such acids when carefully distilled yield a product of light color suitable for making good soaps of light color.

The use of fatty acids, as such, has made it practicable to use soda ash very largely in the place of caustic soda. The former will combine direct with fatty acids making soap from which the glycerine has already been recovered, whereas caustic soda is necessary for the direct saponification of fats into soap, and tedious methods must be used for recovering the glycerine, and, except with the greatest care, the yields will be poor. It will be thus seen that in the use of fatty acids a saving may be effected even in the alkali employed, as soda ash is considerably cheaper than caustic soda per unit of alkali.

Fatty acids suitable for making into soaps are also suitable for making into candle material. Partial solidification on cooling, will, with the aid of pressing, separate the solid from the liquid acids. The former yields commercial stearic acid so extensively used in candle manufacture and the liquid portion yields the oleic acid, or red oil of commerce. Red oil is used for many purposes, one of the most important being in the manufacture of soaps for washing wool. The manufacture of stearic acid and red oil did not originate with the Twitchell process, but the advent of the Twitchell process gave a new and satisfactory method for the saponification of fatty materials at atmospheric pressure with advantages over methods formerly used. Saponification by means of the Twitchell process may be carried out on a larger scale, with less danger and with greater ease than is obtainable by other methods of acid saponification.

Twitchell's first process in which he recommended the use of sulpho-oleic acid was soon very much improved by the use of naphthalene along with the oleic acid during sulphonation. Whatever the chemical action in the formation of this reagent, it is my observation based on many experiments that satisfactory saponification will result from saponifier made as Twitchell recommends, whereas poor results only are obtainable when separate sulphonation and subsequent mixing are tried. I may say that I was among the first to have an opportunity to become acquainted with the process, and that this acquaintance has become closer with added years.

This process has been put to extensive use not only in America but also in European countries.

Twitchell later devoted himself to a method of manufacturing his reagent which would enable him to produce it in a more concentrated form. He accomplished this by methods of washing, extraction, precipitating as an insoluble salt readily convertible into an active reagent, and drying.

Twitchell and others allied with him have been busy in trying to still further perfect the process of atmospheric saponification of fats into fatty acids and glycerine with the result that a new sulphonated reagent with increased efficiency has lately been put upon the market.

The Twitchell process has been so simple in use that one is almost inclined to look upon it as nothing out of the ordinary. On careful thought one is forced to conclude that it is this simplicity which has become almost commonplace that commends it most to the many who have become familiar with it in operation.

An Appreciation

By Herman B. Schmidt

President Twitchell Process Co.

Thirty years is a span of life; practically a generation has passed. In these thirty years there have been in this country profound changes, unparalleled growth, and vast development. The bankers may tell you that the bank deposits have increased maybe ten times in this span of life. The iron people tell us the production of iron has increased about ten times. But what measure of increase can be put upon the developments that increased the chemists' opportunity—how many times? Surely a hundredfold at least.

Only a generation ago, when the industrial chemist started on a career, what had he before him? Simply the obligation to create an opportunity. As an example, going back to conditions then in Chicago, it was hard work to gather together a dozen men at a gathering. There were a couple of iron and steel chemists, two railroad chemists, a couple of metallurgical chemists, one soap chemist, one packing-house chemist, and a couple of assayers and a couple of professors.

The audience will get an idea of how inadequate the conception was of what a chemist's work consisted in. One day, in walking across the stock yards in Chicago, I was stopped by one of the then partners of what to-day is one of the largest institutions of its kind in this country, who said: "What do you do over at Fairbanks'?" Explaining what the routine duties consisted of, what new things had been taken up by the laboratory, he finally said he did not think his institution could employ a man full time at that kind of work; and yet, three months after that interview, that institution employed its first chemist. I

dare say that that institution to-day has at least fifty in its employ.

In Cincinnati the conditions were similar, and if we look back on the chemist's equipment and temporary abode on a far-off lot, or prairie, with no gas, no electric lights, coal-oil lamps, and gasoline torches to work with, good work was carried on under severe conditions. I am always amused when I think of the difficulties of nitrogen determination at that time compared with the Kjeldahl method of to-day. Then we required a glass combustion tube and charcoal furnace and a boy to fan the coals. If he fanned too hard, the glass tube cracked; if he did not fan hard enough, the distillate was colored and you could not titrate it.

Under just such conditions our distinguished guest started.

In comparing these meagre facilities with the magnificent equipments that every college laboratory has to-day, I am reminded of Dr. Wolcott Gibbs who said when one day in his research laboratory the inadequacy of the equipment came up: "Why, do you know how the great Berzelius got his results? Why, all he had were some bottles, a sink and a cookstove. The present generation hardly realizes the huge advantages it enjoys."

Away out in a field, in a lean-to to a still building, Dr. Twitchell, too, had to create his opportunities, and there seeds of progress were sown. There were no fixed lines to work on; every step was capable of researches and these had to be made in order to find the ways in which the chemist could make himself valuable, and gradually the structure grew. Twenty-four years ago next July there was a meeting of the Society of Chemical Industry at Liverpool. One morning, while riding on the second story of a tram car (the two-story horse-car affair that was a characteristic of English streets) reading the itinerary of the meeting, a party slapped me on the back and said, "Are you a chemist?" "Yes." "Oh!" he said, "you are from the States. Where from?" "Chicago, but expect to go back to Cincinnati to live." "Well," he said, "Cincinnati; why, do you know Mr. Twitchell?" "Yes, we went to school together." "Well," he said, "he has made the best contribution to the chemistry of soaps that I know of. His method of determining the percentage of rosin in a soap is the only method that gives us the means of determining what a competitor has in his soap," and then my party said: "Here is my card, I am Dr. Lewkowitsch, and I had the experience of Mr. Twitchell's method in a soap works at Warrington." So our honored guest early in his career had made a valuable contribution to chemistry and was known to every chemist that was in fat and soap lines.

Only a few more years elapsed when Mr. Twitchell was able to announce the working out of the Twitchell process of glycerine recovery. The means employed were so novel that when the German Patent Office was asked to pass upon the patentability of the Twitchell reagent, they doubted that a compound described by Mr. Twitchell could exist. It is needless for me to dwell on what the process has done. You have heard that told to-night.

Just one more word. The young chemists will appreciate much more what Mr. Twitchell has done. His methods, employed in hundreds of factories throughout the world, have necessitated chemical control of operations and so have afforded just that many more opportunities for the employment of skilled chemists in those works. So what one man has done benefits one hundred or one thousand men through a new opportunity, and this is only one example of where the opportunity has grown a hundredfold.

Metallurgy of Cadmium—Raw Materials, Technique and Economics

By Franz Juretzka

Translated from "Metall und Erz" (12:235, 1915)

By Oliver C. Ralston

TECHNIQUE

As the result of the increasing use of metallic cadmium, the possibility of increasing the supply is of importance. In America especially of late the increasing production of cadmium is noticed. It was thought that the following notes would not be without interest to smeltermen and metallurgists.

Some of the common properties of cadmium, as compared with those of zinc, are as follows:

	Cd.	Zn.
Specific gravity	8.6-8.7	7.0-7.1
Melting point	325 deg. C.	420 deg. C.
Boiling point	750 deg. C.	900-1,000 deg. C.

The temperature of condensation is between 415 deg. and 520 deg. C. for both metals.

The principal ores from which cadmium is recovered are zinc blende and calamine ores. In the blende the cadmium is present as the isomorphous greenockite, CdS, not only in the regular sphalerite, but also in wurtzite. In calamine it is present as $CdCO_3$. Usually the cadmium compounds impart a weak lemon yellow cast to the zinc compounds or products with which they are associated. The average run of blendes contains about 0.15 per cent Cd with considerable variations (Upper-Silesian blendes 0.15 per cent, Rhenish blendes less, Sterzinger blendes about 0.2 per cent and the Przibram ore up to 1 per cent Cd). Calamines are usually richer in cadmium. For example, Wiesloch (Baden) calamines contain 2 to 5 per cent Cd and Upper-Silesian calamines 0.3-0.5 per cent Cd and over.

The greater portion of this cadmium in the ore is lost during roasting and calcining and is found in an enriched form in the flue dust, but the latter product is rarely worked up for cadmium. Flue dust from blende roasting often contains 2.6 per cent Cd, usually in the form of the soluble sulphate. After leaching with water it is comparatively easy to precipitate it as CdS by the use of hydrogen sulphide. This CdS as a rule is contaminated with arsenic and can be freed from it by a slight roast. This leaves a brown cadmium oxide, CdO, as a starting point for the preparation of various cadmium salts.

The lithopone factories often have cadmium chloride in their raw $ZnCl_2$ liquors. It is precipitated by the use of zinc dust or by electrolytic means. (Dr. Alberti, Langelsheim, Harz.)

Most of the cadmium on the market to-day is made from the zinc dusts. Zinc dust contains 3 to 8 per cent Cd, according to the original content of the ore.

In the wet way cadmium is sometimes prepared by dissolving zinc dust in dilute hydrochloric acid, the zinc dissolving and leaving a residue of lead and cadmium. Some of the cadmium goes into solution and is reprecipitated by the addition of more zinc dust. This residue is later distilled to recover pure cadmium.

Although this method is very simple it is usually unprofitable. The zinc chloride liquor on precipitation with lime gives a zinc oxide which invariably contains some zinc oxychloride and later in distillation it is very troublesome. (As much as 10 per cent $ZnCl_2$ is retained by the precipitate.) It cannot be washed out and it is lost in distillation as it distills as $ZnCl_2$, passing out through the prolongs, corroding the condensed zinc and making it of little value. The zinc dust is likewise rendered pyrophoric and unsuitable for commercial purposes. The costs of the zinc dust lost by reason of these

objections must be balanced up against the value of the cadmium obtained in the process.

As a starting point for the dry-process cadmium there is used the zinc dust evolved during the first one and one-half to two hours of distillation of a zinc ore. This dust often contains as much as 6-8 per cent Cd. The cadmium content of this dust is higher the sooner the prolongs are placed on the retorts after charging. It seems to be very important to very quickly close and lute on the condensers and place the prolongs in position, after charging the retorts. It is also very essential that all of the dust should be well loosened from the walls of the prolong by pounding with a wooden stick during the process of collecting the dust, as the first dust tends to stick to the walls, due to condensed moisture.

By strict supervision it is possible to get seven to eight kilograms of dust from each prolong during the first one and one-half to two hours of distillation, and from a furnace with three tiers of retorts this means 20 kilograms of dust from each section. This zinc dust is mixed with about 50 per cent of its weight of carbon

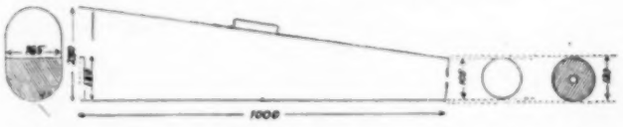

FIG. 1—SHEET-IRON CASING FOR MUFFLES; MEASUREMENTS IN MM.

and placed in a retort of the kind usually used for zinc and distilled for about 22 hours at a dull red heat. In order to insure obtaining a yield of material rich in cadmium during this operation the prolong is removed when the flame issuing from it ceases to have a brownish tinge. For a condenser there is used a conical sheet-iron prolong (see Fig. 1), in which the cadmium, cadmium oxide and some zinc oxide collect. In order to prevent the walls of the condenser from being attacked they must be coated with whitewash and a rather thick coating of cadmium oxide allowed to form.

At the close of the distillation period the condenser is removed, cooled with water and then emptied into a special container. This material will contain about 75 per cent Cd. It is of a gray white color and feels soft and greasy when molten. If it is hard and dry it is a sign that the furnace got too hot and too great an amount of zinc was distilled. Under such conditions it is possible to stratify the material in the container by strong shaking, the particles of zinc tending to collect on the top, where it can be skimmed off and returned to the retort. The residues from the retorts,

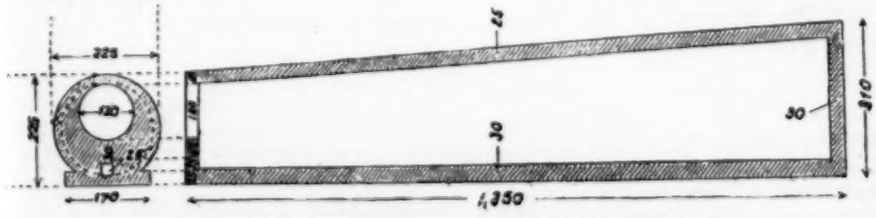

FIG. 2—CAST-IRON RETORT; MEASUREMENTS IN MM.

which contain 45-50 per cent Zn, are returned to the zinc distillation furnace.

The cadmium metal made in this manner is mixed with about 40 per cent wood charcoal, or 60 per cent of high-grade coke, moistened, and placed in cast-iron retorts (see Fig. 2) by the use of ladles and shovels, leaving the front portion of the retort empty for the collection of molten cadmium. The condenser is immediately put on and luted on with clay. Due to the fact that the opening in the end of the condenser is so

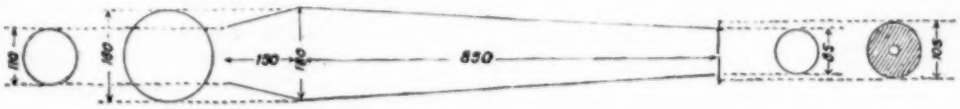

FIG. 3—CASING FOR RETORT, SHEET IRON; MEASUREMENTS IN MM.

small (only about 1 cm.), the gases first generated in the retort issue very quickly and may make necessary the repairing of the luting of the condenser. The design of the condenser is shown in Fig. 3, in which all dimensions are given in millimeters.

The molten cadmium collecting in the front of the retort is removed every four hours by the use of an iron ladle, in order to prevent its taking up too much zinc and iron. Every ten hours the condenser is removed, as a part of the cadmium boils in the retort and is caught in the condenser. During the emptying of the condenser the mouth of the retort must be closed with a brick of the proper shape. The condensed metal, which is usually shot through with little needle-shaped crystals, is dumped back into the forward part of the retort, the condenser replaced and luted on again. This also affords an opportunity to stir the contents of the retort well because the residues have a strong tendency to form crusts. Thirty minutes after the replacing of the condensers it is allowable to completely close up the exit opening in the condenser. Every morning the contents of the condenser are removed and then the retorts can be emptied.

The crude cadmium obtained in this way is removed and collected every ten days into a cast-iron kettle, where it is melted under a cover of oil and cast into

FIG. 4—CADMIUM MOULDS OF IRON WITH TWENTY-FOUR CHANNELS; MEASUREMENTS IN MM. THE CHANNELS ARE 250 MM. LONG

a mould of the type shown in Fig. 4. The sticks of metal are cut off from the "sow" by means of shears and are then ready for shipment. The dross is allowed to accumulate over a number of melts and finally is redistilled.

If the cadmium furnace is run too hot for a few days too much zinc will accompany it and even 0.5 per cent Zn is sufficient to alter seriously the properties of the cadmium. While cadmium of good qualtiy gives sticks of good appearance, medium-grade cadmium gives sticks whose upper ends look dead. Inside these sticks are often some bubbles formed during casting, and on bending these rather stiff sticks they often break at the bubbles. The quality can also be told by the fracture of these sticks. Good cadmium gives a brilliant crystalline fracture, while medium-grade cadmium shows a coarse-grained gleaming fracture and the poorer grades of cadmium give a fine-grained dull-gray fracture. Also a stick of good

quality cadmium will give a rustling sound much like the cry of tin when bent near the ear, while the poorer grades of cadmium will not do this.

In order to convert medium-grade into good-grade cadmium it is placed in the back of a warm retort in which a dam of sand is built, the cadmium distilling from the back end of the retort, condensing in the front end and in the condenser, and giving a high-grade metal with very little loss.

Table I.—Cadmium Production in Upper Silesia.

(By the kindness of Consul Philipp, Breslau.)

Year	Kilograms	Total Value, Marks	Sale Price M/kg.	Sale Price $/lb.
1882	3,521		15.00	1.62
1896	15,527		8.50	0.92
1897	9,840		4.50	0.49
1899	9,840	65,312	21.00	2.27(*)
1900	13,533	82,037	5.50	0.60
1901	13,144	83,003	5.50	0.60
1902	12,825	61,500	5.50	0.60
1903	16,765	81,349	6.00	0.65
1904	24,745	134,661	6.75	0.73
1905	24,568	148,068	7.00	0.75
1906	27,561	181,988	10.00	1.08
1907	32,949	255,064	11.50	1.24
1908	32,795	203,822	7.00	0.75(†)
1909	37,187	198,288	5.25	0.56
1910	41,057	165,166	5.50	0.60
1911	42,575	224,254	6.50	0.70
1912	42,757	267,399	7.37	0.79
1913	38,575	233,812	7.62	0.82

(*) Due to heavy buying for experimental purposes at the explosives testing laboratory in Dresden.

(†) At this time the Joplin district began producing cadmium at the rate of about 7000 to 8000 kilos per year, or 15,000 to 17,500 lb. per year.

Table II.—Cadmium Production in the United States

(By the kindness of Beer, Sondheimer & Co.)

Year	Pounds	Dollars	Cost Per Lb.
1910	5,300	2,846	$0.54
1911	27,000	16,848	0.62
1912	27,000	19,440	0.72
1913	25,000	18,850	0.75

Table III.—Cadmium Imports of the United States.

Year	Pounds	Dollars	Cost Per Lb.
1910	3,083	1,657	$0.54
1911	5,956	3,718	0.62
1912	6,396	4,603	0.72
1913	1,999	1,508	0.75

The Grasselli Chemical Co. is said to be recovering cadmium from cadmiferous dust and from a smelter fume. The American Smelting and Refining Co. is recovering cadmium from a fume in like manner.

The uses of cadmium are rather limited. It is used in the manufacture of Woods alloys, the composition being Bi 50 per cent, Pb 26.7 or 25 per cent, Sn 13.3 or 12.5 per cent and Cd 10 or 12.5 per cent, the melting pts. being 60.5 deg. C. to 70 deg. C.

In the United States it has found considerable application in the manufacture of fusible plugs in automatic fire extinguishing apparatus. One analysis is 50 per cent Pb, 27.5 per cent Sn and 22.5 per cent Cd. Lipowitz metal is similar to Woods metal and is often used by goldsmiths in soldering jewelry.

The amalgam used for filling teeth contains 26 per cent Cd and 74 per cent Hg. Cadmium is also used in the sulphide form for oil and china painting, as iodide and bromide in photography, as the chloride in colormaking and in calico printing. The sulphide is often used in coloring silk, and the sulphate is occasionally used for affections of the eyes.

ECONOMICS

If we assume that the dust from the distillation of zinc is collected for the first one and one-half hours after charging in a zinc smelter containing 30 furnaces of 120 retorts each, and that the dust contains 5 per cent of cadmium, and further, assuming the average figure of 20 kilograms of zinc dust from each furnace during this 1.5 hour period, and 900 furnace days per month, it can be seen that the production is $20 \times 900 = 18{,}000$ kilograms of zinc dust per month. This is 18 metric tons or 18 long tons of dust. The dust consists of 5 per cent cadmium, and assuming 35 per cent recovery it is found that by reasonable care a 35 per cent yield is possible.

Forty to 50 per cent of the cadmium is lost during the enrichment of the dust and 20 to 25 per cent. remains in the residue. It is probable that the volatilization losses and the material absorbed in the muffles account for about 40 to 45 per cent. of the cadmium. Only 1.5 to 3.5 per cent of the zinc in the original dust is vaporized during removal of the cadmium.

If the recovery is 315 kilograms (696 lb.) of finished cadmium of 99.5 per cent grade each month, and if this sells for the average price of 7.75 marks per kilogram (84 cents per lb.) the total monthly receipts will be 2441 marks ($581).

Against this income must be set the following costs:

	Marks	
1. For collection of the dust	90	$22.40
2. Labor on cadmium furnace, 1 man during the day (30 days) 4.50 marks	135	32.10
3. Labor, part of one man's time at night	15	3.57
4. Disposal of residue	9	2.14
5. Nineteen ordinary muffles at 4 marks each	76	18.10
6. Twenty tons coal at 14.50 marks ($3.46)	290	69.10
7. Depreciation and amortization	50	11.90
8. Five per cent loss of zinc, at 5 cents lb.	302	72.00
	967	$232.31

So the net profit per month is 1474 marks, $351.

The installation costs are as follows:

	Marks	
Furnace construction	1,000	$238.00
Twenty condensers, at 5 marks each	100	23.80
One cast iron retort	150	35.70
Shears, molds, etc.	250	59.50
	1,500	$357.00

The life is calculated at about four years. This makes the rate of amortization per month 31.25 marks, while 50 marks was allowed in the above calculations. The iron retorts deteriorate more rapidly and the extra 18.75 marks is allowed for this purpose, although it only requires about 15 marks, leaving 3.75 marks for the necessary small repairs.

The cadmium furnace can easily be installed along one wall of the furnace room of the zinc smelter, causing very little change in the regular routine, and is as easily attended and served as the muffle tempering furnaces.

A plant of the above description would produce annually 3780 kilograms (8350 lb.), and at the above prices would bring in a net profit of about 17,688 marks $4,210). It is assumed that the zinc dust thus treated cannot be sold, due to lack of market or of some undesirable quality.

It can be easily seen that the making of cadmium should be very profitable business when cadmium is worth more than 7.50 marks per kilogram (81 cents per lb.). Furthermore the installation costs are low and it is easy to discontinue operations when the cadmium market is low. This is of particular advantage, and besides the small cadmium furnace is not injured in the same manner as a zinc furnace by being cooled off, and it can be easily converted into a retort tempering furnace.

Translator's Note.—Much of the metallurgy of cadmium above described is not new, and indeed a much better description of that subject is found in Ingalls "Metallurgy of Zinc and Cadmium." However, the ease of recovery of cadmium and the small expense to which the capitalist is put in order to recover cadmium from zinc ores should be welcome news to American zinc smelting men. It is to be regretted that the commercial state of the art in the United States is such that it is very hard to get definite information on the technique of the metallurgy performed and on the present use of the product. It is known that others besides the Grasselli and the A. S. & R. companies are now marketing cadmium in the United States. Some of the A. S. & R. cadmium, as well as that of some of the other plants, is from the flue dusts of lead ores. Much of the present production would not be profitable, or at least would be much less profitable on 75c. cadmium. Hence the secrecy. It is to be hoped, however, that technical advances will be such that more than 35 per cent recovery will be possible and that the number of producers will soon become such that information on the subject can be given out without imperilling the interests of the parties concerned. O. C. R.

New York Meeting of American Institute of Chemical Engineers

The sessions of the first day of the winter meeting of the American Institute of Chemical Engineers, held in New York City, from Wednesday, Jan. 10, to Friday, Jan. 12, were reported in our last issue. On Thursday an excursion was made to Perth Amboy, New Jersey, and in the evening a subscription dinner was held at the Chemists' Club. Mr. Maximilian Toch was toastmaster, and the speakers included Messrs. Olsen, Hendrick, Baekeland, and Baskerville.

On Friday morning a technical session was held at the Chemists' Club at which two papers were read. EUGENE E. AYRES, JR., of the Sharples Specialty Co., presented an able paper on "The Effect of Centrifugal Force on Colloidal Solutions." This will be printed in full in our next issue. In discussing the paper, Dr. Andrews asked whether with a solution containing particles of two different sizes, such as microns and amicrons, the removal of one size would not be hindered by the other; in other words, whether there would be a complete separation of a definite size when the force necessary to separate that size was applied. Mr. Ayres thought that in general a certain amount of another size would be carried down, but that it depended on the nature of the materials and on the electrical attraction of the particles. With some substances, a more complete separation of different size particles could be effected than with others. Dr. Richardson and Mr. McCue also discussed the paper.

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The second paper was presented by Mr. CHARLES L. CAMPBELL, of E. B. Badger & Sons Co., who spoke in a very interesting manner on "Recent Developments in Distillation and Absorption." Publication of this paper in full is reserved for a future issue.

On Friday evening a technical session was held, at which the new president of the Institute, Dr. G. W. THOMPSON, read his address on "The Human Side of the Development of the Chemical Industries." The first part of this paper was printed in our last issue, and the concluding part will be found below in this issue. The paper was discussed by Dr. Frerichs, who spoke of welfare work done at his plant, especially in the matter of shorter hours, workmen's insurance, etc. He said the results obtained from better working conditions fully justified their adoption.

The second paper of the evening was read by Mr. F. W. SPERR, chief chemist of the H. Koppers Co., on the "Recovery of Benzol from Coke Oven and Illuminating Gas." This paper is printed in full on page 135 of this issue. In discussing this paper, Dr. Frerichs mentioned a distilling column used in Germany which was filled with short cuts of pipe of different diameters, as, for instance, 1 in., 2 in., and 3 in. The cuts are about as long as the diameter. A well-known manufacturer of carbolic acid in Germany has used this column with success, and a much shorter column can be used. Mr. Sperr said there was a tendency to make the column more simple, and to place more dependence on the dephlegmator. Mr. Campbell said he was familiar with the system, but not from actual experience with it. He thought it quite possible that this short column, filled with cuts of pipe, would give the same results as a long one with plates. Mr. Peterson asked whether it was possible to recover benzol from producer gas. Mr. Sperr said he had examined one producer and did not find enough benzol to warrant commercial recovery. The possibilities of recovering ammonia, however, are very great. In the by-product coke oven about 25 lb. of ammonium sulphate are recovered per ton of coal used. It is possible to recover from 80 to 85 lb. of ammonium sulphate per ton of coal used in the gas producer.

The last paper of the evening was by Mr. ANDREW M. FAIRLIE, on "The Fairlie Method of Control of the Chamber Process for Making Sulphuric Acid." This was presented in abstract by Dr. Olsen, as follows:

The deficiencies of the old methods of controlling the chamber process are pointed out, and the Fairlie method is described. The latter (technical description in U. S. Patents Nos. 1,205,723 and 1,205,724) has been in continuous daily use at the plants of the Tennessee Copper Company for six years. It consists in determining the percentage of sulfur dioxid in the chamber gases at some point near the front end of the chamber system, and in comparing such percentage with the percentage sulfur dioxid in the burner gas, before admixture with niter fumes. The comparison shows, after experience, that a certain ratio between the two sulfur dioxid percentages must be maintained in order to secure the best results in the Gay-Lussac tower. What this desirable ratio is must be determined for every possible grade of burner gas. Once determined, the desirable ratios are arranged in tabular form on a card, which is framed and secured in a place convenient for reference by the chamber operator. This operator, by taking tests frequently of the burner gas and the front chamber gas, obtains accurate information as to the speed of oxidation of sulfur dioxid in the chambers, and obtains this information in time to apply the proper remedy and to adjust correctly the proportions of niter admitted to the process, whenever anything is about to go wrong.

The usual analytical method for the determination of sulfur dioxid is altogether unreliable as applied to gas mixtures containing the oxids of nitrogen. An improved method has been devised, and this method is described in detail. Without this improvement in the method of determining the sulfur dioxid in chamber gases, the development of the new method of chamber control would have been impossible.

The Human Side of the Development of Chemical Industry*

By G. W. Thompson

(*Concluded from page* 81)

I think that I have said enough along this particular line to indicate to you my views as to what the chemist should do in the direction of trying to develop a popular appreciation of his work. If there is truth in what I say I am quite sure the open mind of the average chemist will discover it. If I am wrong he will soon find the vulnerable point in my argument. I would like now to pass to another aspect of this question, which relates more particularly to the chemist himself. What I have said so far deals for the most part with the attitude of mind of the chemist toward the public. What I propose to say now deals with the attitude of mind of the chemist towards himself. I have referred to a relation existing between the chem-

*A paper read at the Ninth Annual Meeting of the American Institute of Chemical Engineers, New York City, January 12, 1917.

ist and the public. In this relation there are two parties, the public on the one hand and the chemist on the other. The problem before us is: What should the chemist do to develop and improve his attitude of mind towards himself? This is an exceedingly difficult subject, and if it were not that I am fortified by a belief in its importance, I would not dare to speak upon it. I cannot think of anyone holding a higher opinion of chemistry as a profession than I do, and all that I am saying is actuated by a profound belief that the chemist is only beginning now to climb the ladder that reaches to a power of service unequaled by any other profession.

The delicacy of this subject is such that I feel impelled to approach it in the form of questions. In putting these questions, let us consider first some facts, and then we can come to the questions themselves. Let us first consider the young chemist just leaving his college or university. Like all students graduating in various courses, he has yet to learn what business life really is. They think they know what it is, but we know that there is no college or university that teaches it. The difference between the chemist and most other graduates is noticeable in this: The chemist enters a more or less isolated laboratory; most of the others go directly into the commercial world. The chemist in this laboratory—be it analytical or research—is not dealing with people, but with inanimate material things. He may stay in this laboratory a few months, a few years, or for his lifetime, as the case may be. He may be doing invaluable work, but—here is the question: Is he taking his proper place as a man in the world of men? Is he not too much isolated? Is he in his occupation gaining directly in his power over other men? Is his social instinct being developed or is it being retarded in its growth?

If we think that laboratory chemists as a general class are taking their proper place in the world in which mind reacts upon mind, there is nothing more to be said; but if we think with his intelligence and education, the chemist has a mission outside of the indirect service he professionally renders to society, then our question leads us to urge that the barriers which ordinarily isolate the laboratory chemist should be broken down so that he can get out more into the pulsating business world. He may not be able to do this alone, and perhaps the duty devolves upon us; perhaps there are some of us who have it in our power to help bring about this liberation. If we want chemists to have a greater personal influence in the world, and by this we mean to include those chemists who are subordinate to us individually, is it not proper for us to ask ourselves whether at times we do not rather selfishly stand in their way? Cannot those of us who are employers of chemists give our employees more opportunity to become familiar with the commercial aspects of the work they do? If we do this, will they not become better and more profitable employees? In our dealings with non-technical men representing large business interests, could we not more regularly and persistently ask to be brought into contact with their chemists if they have them, thereby helping to pull them out of their seclusion? If we are asked to organize a laboratory in a commercial concern, could we not say that the work of the chemist would be greatly helped if it were so arranged that he would know the actual use to which his reports were to be put? Could we not do something in urging that the laboratories in which such chemists are expected to work should not be hidden away in inaccessible places? Could we not do many things suggested by the occasion to break the bonds which the young chemist, led by false hopes, may have often slowly forged? Is it not possible that with our colleges to-day filled with students of chemistry, these students should be advised against accepting positions of an isolated character?

You will see that I am basing my argument on two hypotheses, which are intimately related. One is that social relationship is one of the great purposes of life, and the second is that without such social relationship no individual can really be successful in the development of any important enterprise. I have argued, therefore, that the chemist's success depends upon a social recognition of his worth, and second, that the chemist should enter into as broad social relationship as possible. In popular terms one of these means that it pays to advertise, and the other means that the chemist should get out upon the broad highway.

I propose now to say a few words on the disadvantage which is sure to result from antagonism. I propose to advocate in all our dealings a conciliatory spirit. It would seem almost unnecessary to say that if the chemist is to advertise, he should avoid offending the persons who read his advertisements, just as it is perfectly obvious that the salesman who is trying to sell goods should not make himself *persona non grata* to the purchaser. A good salesman—and that is what we should all try to be in one form or another—subordinates his own views and makes them as inconspicuous as possible, but no less effective. What he tries to do is to find out the views of his customer so that he can furnish the customer with what he desires. I wonder if sometimes chemists are not a little more pugnacious than they should be. I sympathize with the feeling of an analytical chemist who will set his results up against the world and insist that he is right, but many years of experience have taught me that the chemist who does this without regard for the effect upon other chemists is doing a very foolish thing. I believe it is a good rule never to put anybody "in wrong." I believe it is far better, even in the case of commercial opponents, to help the commercial opponent out of his difficulties rather than to push him in deeper. Again, are we not at times a little too virulent in asserting our ideas respecting public officials—administrative, legislative and judicial? They are human beings just as we are, they are representatives of the whole people, and if their views differ somewhat from ours, is it not very much better to work patiently and steadily to change their views, directing them into constructive paths, rather than to confirm them in their views and drive them to unwise extremes by opposing them vigorously?

Let us take as an illustration a subject on which perhaps chemists are divided at the present time, although the division may be by no means equal. Many chemists are seeking to have our national government help the chemical industry to become more firmly established in this country. Some think it can be done by subsidies, others by protective tariffs, others by embargoes, and so on. Now I would not argue in this meeting for or against any of these propositions. I simply say that if you are in favor of any one of them it is unwise because he opposes you to incur the antagonism of any public official, even if he be of an opposite political faith. Practically all public officials have their ears to the ground; they are trying to find out what their constituents want, and no one should blame them for this. In so far as they are representatives they are only doing their duty. It is perfectly proper for us to try to convert a public official to our way of thinking. It is still more proper for us to try to convert the people he represents to our way of thinking, but I consider it the height of foolishness to attribute to public officials dishonest purposes, ignorance, stubbornness and all the other sins of commission and omission. My

point is very clear—such accusations do not lead you anywhere but into trouble.

I believe firmly that the obstacles which we meet in our social acts in endeavoring to get our plans consummated do not differ essentially from the obstacles which the chemist meets in the ordinary routine of his work. If he finds a chemical reaction is not progressing satisfactorily, he does not close his eyes to this fact and denounce some devil or anthropomorphic god because it has interfered with his work. He tries to find the cause of the trouble and remove it. So I say that if you have social obstacles to overcome, find their cause and remove it, bearing in mind that there is no easy way by which this can be accomplished—in fact, that there is only one way—education backed by goodfellowship.

We have heard in recent years a great deal said about efficiency; it may be that some foolishness has been uttered. The word "efficiency" is used in various ways. We have the efficiency of a process considered by itself; we have this efficiency as compared with other processes; we have mechanical, chemical and human efficiency. I am interested primarily in this paper in human efficiency. What does it mean? Broadly speaking, it means co-operation without friction. Perhaps we should say that co-operation cannot be had with friction. Of course, it would be absurd for me to attempt to solve the eternal problem of human friction in a paper of this kind. All I can do is to indicate some ways by which it can be reduced. While the realization of frictionless humanity is far away, symptoms of it have certainly appeared at times. Efforts in the direction of reducing human friction conspicuously numerous at this time are to be found illustrated in factory welfare work, workmen's compensation acts, pension systems, etc. All of these have been justified by the increase in human efficiency they have produced. A man whose welfare is of no account is not a good workman.

Human efficiency, however, demands right men in the right places. The difficulty that the employer experiences is in knowing whether he is picking the right man for the place or not. If the man has been educated rightly the employer is better able to form an opinion. Particularly is this true regarding foremen and the higher grades of labor. Graduates of such institutions as give technical education are made more nearly right for places in chemical and other industries. More general industrial education such as that being advanced in some states will undoubtedly add to human efficiency. Even then the making of a man suitable for a given position comes after he commences employment and is largely the work of the employer himself.

Industries do not merely require men, however; they are complicated machines of which the men form a part. The proper fitting and adjusting of these machines to the men employed is the big problem only partly worked out as yet. Each industry has its own requirements, these requirements continually changing with the growth of society. Who has not been face to face with the requirements of an industry? These requirements are almost vitalized by competition. Industries come and industries go, they are planted and they are reaped, but their volume increases from year to year. We must not, however, allow ourselves to think of industries and industrial processes as though they were other than inanimate things. We should not waste our tears over their rejection when they are worn out, provided others take their place. This is growth—the sloughing off of the old and the putting on of the new.

The chemical engineer has a great deal to do with the development and administration of new processes. Many an old fogy has damned the chemical engineer, who has rendered his processes and his equipment antiquated and idle. The mechanical engineer also has received his malediction. We are sorry for the old fogy and would, if it were possible, provide insurance for him, but we would do nothing to retard the fate of his equipment.

The development of a new process is the result of many separate factors. New processes are like the waves of the sea—they cannot rise much higher than the level of the sea itself. They rest on general industrial growth and are not much above the level of that growth. This is true of all processes, chemical processes included. Their growth depends upon the growth of the mechanical art, its methods of fabrication, and all the materials that enter into construction. It depends upon highly developed foundry practice, mining, building construction, farming and transportation, and last, but not least, all those branches of human development which are manifested in the home, social organization, governments and international relations. I emphasize this human factor because so many processes have had to wait years for the time to ripen for their introduction, indicating, in other words, that not alone should our endeavors be directed to the development of processes, but they should also be directed in a general effort to accelerate the coming of the fullness of time. The fullness of time means that the social level has been sufficiently raised.

New processes are of two kinds: First, those which provide improved methods for making old and well-known products, and second, those which involve the making of new products to take the place of old, or new products which serve entirely new purposes. A new process which is intended to provide methods for making an old product, if it is to be successful, must involve economy of some sort—economy of material, investment, time or labor. Necessity creates the demand for such new processes. Competition, domestic and foreign, is the impelling force. The wise manufacturer recognizes that the development of a new process may be his salvation. It is impossible in this paper to discuss all the demands which compel the invention of a new process. We will discuss only the human or labor element.

If labor here in the United States is higher in price per unit of product than it is abroad, it is manifest that with free competition the manufacturer must so modify his process that this item in cost will not militate against him. He may not be willing to modify his process, and his first instinct may be to limit the competition by a protective tariff or some similar restrictive measure. One objection to this, except as a last resort, is that it removes some of the pressure which makes for improvement of process. We may dislike the pressure, but we know after all that it is a good thing. We cannot allow anything to interfere with such pressure as makes improvement necessary. Such improvement may be possible. It is much wiser to insist that it is possible than to insist that it is not. Success is often accomplished by doing what is apparently impossible, but assuming that the manufacturer cannot get the protection he wants, how will he go about improving his process? We will offer only a few suggestions.

The first consists in manufacturing in large units. By this means overhead charges are reduced and materials can be handled more cheaply by mechanical means, thereby either directly or indirectly reducing the cost of the labor factor. In this direction it would appear that the United States has been pre-eminently successful; there is probably no country in the world which

equals us in this line of development. The second consists in subdivision and specialization of labor. It is obvious to all that it is through this method that most of our industries in his country have been successful. The third is radical development of process. If we take a given process and consider all of the operations, step by step, we are able tentatively to classify these steps into two kinds—the essential and the apparently necessary. The apparently necessary step is not by any means an essential step. An apparently necessary step is one that the state of the art has not eliminated. An essential step is one that we feel justified in saying cannot be eliminated, no matter what the state of the art is. By a radical development of process it may be possible to eliminate apparently necessary steps. The burning down of a house in order to roast a pig was in the mind of the Chinaman of fiction an apparently necessary step. It was, however, eliminated by the efficiency engineer of his day. Fourth, by doing by machinery what was theretofore done by labor. An essential step in a process may still appear essential, although instead of performing the step by manual labor it is done by machinery. This much does not involve the elimination of a step. Doing by machinery what was theretofore done by labor is the obvious method of reducing labor costs. It usually entails, however, additional cost for investment, power, and repairs, and also the employment of a higher class of labor. It is perfectly obvious that where labor is cheap machinery is unnecessary, but that where labor is high competition compels the use of machinery, and that this is the proper and natural order of things.

This is perhaps to you a somewhat academic presentation of the methods to be followed in studying how a process can be improved. If I should go into the methods by which new processes for making old or new products might be worked out, it is probable that this study would be still more academic, and I will not attempt here to touch upon that branch of the subject. What you may consider academic in what I have said, however, has a very practical bearing upon the general subject I am endeavoring to present. As I have already indicated, I am interested in human efficiency. Mechanical efficiency that does not lead to human efficiency is of rare occurrence. Considered in the most general economic terms it is doubtful if it ever occurs. It is natural for us to think of human efficiency as a means rather than an end, but I would reverse this relation and ask you to consider human efficiency as more of an end than a means. It is desirable that we should have high-priced labor because high-priced labor usually means greater intelligence and higher character.

A more highly developed social organism is one of the noblest objects for which one can work, and all efforts spent on the development of its parts is well worth while. If you believe with me that an appreciative public is necessary for the proper growth of the chemical industry, you will also agree that we need a public which shall have the power of appreciation which can only come as a result of the general raising of the level of social conditions.

The chemist by working for improvements in processes involving a saving of labor, and at the same time involving the employment of a better grade of labor, is contributing his part to the better development of a high social organism. If the chemist, however, simply endeavors to improve a process without regard to the possibility of that improved process involving the employment of a higher type of labor, then his work is incomplete. It is true that his process may with cheap labor be able to manufacture products which are used by the entire community, and which consequently can be sold at a reduced figure and thereby benefit society, but many difficulties will lie in his path if he does not at the time that he reduces the quantity of labor necessary in the process also create a demand for a higher quality. I therefore ask those of you who are engaged in the development of processes, such development being forced by competition and the requirements of the industry, to consider whether it would not be better for you to put your mind in the attitude that in your development of process you may possibly be able to get better results by the use of more intelligent and higher priced labor than you could by sticking to low-priced labor and possibly handicapping yourself and your process and preventing its fullest development.

I have endeavored in this paper to present several aspects of a very large and important subject. Some parts of it may appeal to you and other parts may excite your opposition. In the main, however, I believe all of these parts are related to each other consistently and logically. If you believe as I do, that a better social organism is the highest purpose for which anyone can work, you will accept what I have said and include in the proposition many extensions on which I have not touched. If, however, your minds are more practical, I think you will accept many of the things I have presented to you purely on account of their practical value. Therefore from whatever standpoint you approach the subject, am I not correct in stating that practical business success in all lines of business, including those involving the use of chemistry, is dependent upon popular appreciation, is dependent upon social growth, on which the power of appreciation rests, and that everything which tends to increase the power of appreciation helps appreciation itself, and that anything that increases appreciation increases the chance of success of a business enterprise. Or to put it negatively, anything that interferes with an increasing power of appreciation, anything that tends to prevent appreciation or creates those antagonisms which operate against appreciation is pretty sure to hinder the growth of a business enterprise.

If this fundamental proposition is accepted, we can readily see how important it is for the chemist in attempting to build up chemical industry in the broad sense to do everything in his power to raise the general level of human knowledge and education and of social conditions, for it is that level that determines the power of appreciation. Assuming this power of appreciation to exist and to be growing in strength, you will also, I think, agree with me that the chemist should do everything in his power to create a greater appreciation of the value of chemistry in solving the problems of industrial life, for it is only through such appreciation that the chemist himself will be able to exert fully that ability for service which we all believe he possesses. But if the chemist is to impress himself on the public through legitimate advertising, should he not also endeavor to develop that attitude of mind which makes him continually a factor in social growth? Should he not break away from all influences that tend to isolate him, and that, if they do not make him a peculiar being, at least have the effect of preventing him from having the fullest influences over others? Should we not do everything in our power to broaden the horizon of the chemist, to increase, as it were, his circulating power in the social organism? Should we not, as chemists, by very simple methods do all we can to pull chemists individually out of all such surroundings which tend to narrow and handicap them?

Now having done all of these things, should we not go a step further and recognize the peculiar position which the chemical engineer occupies in the develop-

ment of chemical processes? Our minds naturally operate discontinuously. We think of a chemical process and its development as an independent thing, as though it were not a part of all of the other processes continually operating in society. We think that with the development of a process our work is ended; we think that with cheaper manufacture of given products we can sit down with satisfaction and consider our efforts successful. But philosophers tell us that there is no such thing as discontinuity, that everything runs into everything else continuously and is a part of a complete whole. Some fancifully have said that if a man could destroy a single atom, the universe would fall to pieces. This is fanciful but it expresses a true conception. There is such a thing as solidarity—not the solidarity of labor, not the solidarity of industry, but more surely the solidarity of society. All things operate in circles. We have continuous production and continuous consumption, in which material things circulate around and around, never completely stopping. This is so of all human affairs. Effects are unending. All the ends we work for are but the means to other ends. The development of a process was the end yesterday, but to-day it becomes a means—a means by which the social level is raised, which in its turn becomes a means by which other processes are developed.

This is why I have expressed my opinion that in the development of a process it can hardly ever be said to be complete unless it results in the substitution of quality of labor for quantity, whenever such a development has for its purpose the saving of labor. Development of a better quality of labor is essential if we are seeking broadly to increase the power of appreciation on the part of the public. It would be manifestly foolish for me to advocate that chemists should seek to impress Hottentots and Fiji Islanders with the power of service in chemistry. It would take centuries of education to bring them up to the point where we of America are to-day. It is equally foolish to think that we can expect as much appreciation from common labor as we can from intelligent labor. In saying this I make the assumption with which I hope you will agree—that every member of society, the ignorant and the wise, the poor and the rich, the bad and the good, the sick and the well, are all integrally a part of society, and each one has his individual influence in determining the average social level which measures the power of appreciation.

I have endeavored in this paper to avoid taking any position which is negative in its character. I do not believe that there is such a thing as a negative force; the nearest we come to it is inertia. I have endeavored to make positive suggestions which I submit for your consideration with the daring hope that these suggestions may find lodging places, temporarily it may be, in your minds, and if, after these ideas have stayed in your minds for a short time, they then take their flight, I have the still more daring hope that after you have forgotten them they may, though unconsciously to you, have left some faint imprint.

Volatility of Gold at High Temperature in Atmospheres of Air and Other Gases*

BY W. MOSTOWITSCH AND W. PLETNEFF

In the experiments to be described gold was used which was produced and purified by a modification of the method of Krüss (Liebig's Ann. 1887, vol. 43, p. 237). The gold was precipitated from a desilvered solution of Au Cl, according to Vanino and Seemann (Berl. Ber. xxxiii, 2, 1908) by means of H_2O_2 and KOH, washed and melted under borax. The experiments were conducted in a horizontal Heraeus furnace.

In the *preliminary experiments* 355 to 530 mg. of gold were fused for 30 minutes at temperatures up to 1400 deg. C. in an unglazed porcelain boat (which weighed 2g. and had been heated to 1300 deg. C.) in streams of dry gases of air, CO_2, CO, N_2 and O_2. The amount of gas used was in all experiments 800 cc. The volatilization was determined from the loss in weight of the gold.

The loss of gold in a stream of air was observed only by previous weighing and weighing at each temperature. The results of the tests, which were carried out at temperatures of 1100 deg., 1150 deg., 1200 deg., 1250 deg., 1300 deg., 1350 deg. and 1400 deg., are given in a table in the original Russian publication. From the tests the gold was found to undergo no loss, on melting at 1150 deg. C. for 1.5 hours, at 1200 deg. C. for 2 hours, at 1300 deg. C. for 3 hours, at 1350 deg. C. for 1 hour, at 1400 deg. C. for 2.5 hours in air.

In the experiments made in streams of O_2, N_2, CO_2 and CO there were no losses found up to 1400 deg. C.

In the *final experiments*, which were more accurate, the gold was in a chip of a quartz tube (pyrometer protection tube) which weighed 0.2 to 0.3 gram. Weighings were made on a delicate balance by means of a microscope. The gold, quartz chip and silica boat were weighed exactly, before and after heating. The gas was conducted through the furnace at a pressure of 2 to 3 mm. Hg. For each temperature the quartz chip with the gold was kept in the furnace for exactly 30 minutes.

Experiments with O_2, N_2, CO_2, CO.—Only in the first melting was a loss observed, which was caused by the gas content of the freshly prepared gold being weighed. Otherwise, between 1250 and 1400 deg. no volatilization was observed.

According to T. Rose (Metallurgy of Gold, 1906, p. 6, and Journ. Chem. Soc., 1893, lxiii, 714) this loss is considerable.

Experiments in a Stream of H_2.—Thirty tests were made in an atmosphere of hydrogen; some in purified hydrogen from a cylinder and others in hydrogen obtained from pure zinc and sulphuric acid. Up to 1100 deg. no loss was observed. From 1200 deg. on volatilization began and the loss increased with the temperature and duration of heating. The results from one series of tests using 400 mg. Au are as follows:

Temp.	Duration of Heating	Loss in Mg.	Per Cent Loss
1,250 deg. C.	25 minutes	0.22	0.055
1,300 deg. C.	25 minutes	0.35	0.090
1,350 deg. C.	25 minutes	0.42	0.105
1,400 deg. C.	25 minutes	0.98	0.250

If a curve is plotted illustrating the relation between volatility (as ordinate) and temperature (as abscissa) it will be found to rise quickly from 1350 deg. C. on. The quartz chip which contained the gold, the silica boat and the heating tube were colored an intense red, while with all other gases no color was observed. A colloidal solution of gold in quartz is formed ("ruby-glass"). In the absorption liquid (H_2SO_4) gold could be determined qualitatively.

CONCLUSIONS

1. Chemically pure gold is not volatile in atmospheres of pure air, O_2, N_2, CO or CO_2 at temperatures between 1100 and 1400 deg.

2. Chemically pure gold is volatile in hydrogen. The volatility becomes noticeable at 1250 deg. and increases with the temperature and duration of heating. What is the cause of this volatility in hydrogen? Is it a result of direct vaporization of the gold, or is it caused by the formation of a volatile compound of gold and

*Translated in abstract from the Journal of the Russian Metallurgical Society, 1915, No. 3, pp. 410 to 421.

hydrogen? If the gold is directly vaporized, then we could also observe this phenomenon in other gases. The experiments in air, O_2, N_2, CO and CO_2 did not show this.

There remains the supposition that gold forms a volatile compound with hydrogen, Au_2H_2, at temperatures over 1200 deg. This is unstable and breaks up into $H_2 + Au_2$. From this the characteristic coloring of the quartz boat, tube, etc., can be explained, which is connected with the formation of a colloidal solution of the gold in the quartz or the ruby glass. This is the more probable when we consider the analogous phenomena with copper. By continued heating of copper in hydrogen, Leduc (Comp. rend., 1891, xciii, 71) observed the formation of the hyacinth red compound Cu_2H_2, which was partly volatile. This explains also the red coloring of the refractory glass tube in which copper is heated in hydrogen in order to purify the latter from oxygen. In addition, we know a series of metals which form volatile hydrogen compounds, for example: Sb, Ba, Ge.

Tomsk, Russia.

Development in Chemical Engineering Equipment*

By H. D. Miles

President Buffalo Foundry & Machine Co.

As it is impossible in the time at my disposal to adequately describe the development of chemical engineering equipment, I shall only briefly review some of its more important phases as they have come under my observation in the manufacture of chemical equipment by the Buffalo Foundry & Machine Company, of which company I am the president.

This company was organized sixteen years ago on what at that time was considered a radical departure, namely, the operation of a modern foundry on a scientific laboratory-controlled basis. At that period the large majority of foundries were operated by rule-of-thumb methods, and no attention was paid to the chemical composition of the metals used. Metal mixtures were made on a grade basis, known as Nos. 1, 2, 3, and 4, gray forge, scrap iron, etc., the grade being determined by the appearance of its texture rather than by its chemical composition. Very little attention was paid to the percentage of different elements contained in the iron. Frequently what appeared to be a high-grade No. 1 pig iron would, when analyzed, prove to be an inferior grade.

This laboratory control established a reputation for quality and accuracy, and chemical castings, demanding the highest developed standards, immediately became one of our principal products.

It is now fourteen years since we entered this field, and for an active beginning joined issue with European manufacturers who were exporting into the United States the large pots used by caustic manufacturers, and who largely dominated the American market as the domestic product was inferior. After careful research and development, assisted by the co-operation of our customers, we were finally able to produce caustic pots of a better quality, that is, giving longer life, than those being imported from Europe.

We next turned our attention to chemical retorts of one type or another for handling different acids, and to acid eggs, and acid kettles, and ultimately obtained equal results in the manufacture of these.

After our success with these lines of chemical equipment, and several years before the outbreak of the present European war, we entered the field as manufacturers of vacuum dryers, pumps, and condensers, which apparatus has to-day so wide an application in the chemical field. We developed a full line of vacuum dryers, consisting of shelf dryers, rotary dryers, drum dryers, and vacuum drying and impregnating equipment, as well as the auxiliaries which go with such apparatus, namely, vacuum pumps, condensers, expansion tanks, reclaiming devices, dust collectors, etc.

This equipment, which we have highly developed with new and patented devices, is especially useful where rapid drying free from atmospheric variations is required, or where in order to avoid injury to the materials under treatment, drying must take place at low temperatures.

In this connection I wish to call attention to our vacuum drum dryers, which are constructed to dry in large quantities and at low cost without practically any loss of material, emulsions, pulps, extracts, white lead, glue, milk, acids, dyes, and other liquids containing solids. These liquids are reduced to dry forms economically and quickly and without danger of injury to the quality of the material.

We have so far manufactured five sizes of vacuum drum dryers, the smallest having a drum 2 ft. in diameter by 20-in. face, the largest 5 ft. in diameter by 12 ft. face. All sizes are so constructed that they may be easily cleaned and kept in sanitary condition, which is a vital consideration when handling food products. The smallest dryer is so constructed that the casing over the drum can be readily moved back on a track so that free access can be had to all parts of the interior. The larger types are so arranged in size and convenience that a man can enter the casing and scour all parts of the interior.

Our patented method of applying the liquid to the surface of the drum is the result of many developments in our particular machine, and the present arrangement assures a very uniform coating on the drum as well as a large output. There is a large reservoir in the bottom of the casing for holding a considerable quantity of material to be dried. This material is taken, as required, by a circulating pump located beneath the dryer and delivered to a supply pan immediately under the drum and slightly in advance of the knife or scraper which removes the material. Only a small section of the drum surface comes into contact with the liquid

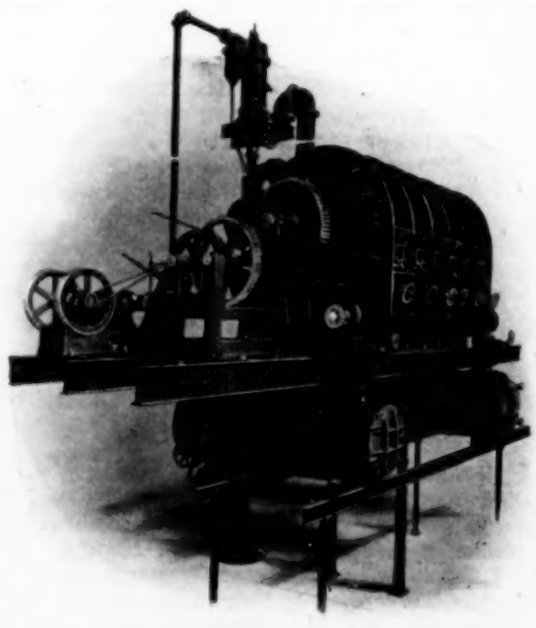


FIG. 1—VACUUM DRUM DRYER

*A paper read at the New York meeting of the American Institute of Chemical Engineers on January 10, 1917.

material and, therefore, over three-quarters of the drum surface is active at all times in drying. The material is forced in the pan under sufficient pressure to insure a uniform coating on the drum. The extra supply of liquid, which escapes on the side of the pan where the film comes out, overflows into the reservoir in the bottom of the dryer. By the time the material reaches the scraper it is dry enough for removal. It is automatically scraped from the drum, falls into a conveyor, and from there is removed to a receiver. Two receivers are used, one on each end of the machine. While one is being loaded the other is unloaded, an arrangement which permits the machine to be operated continuously.

Where the drum dips into the main body of the liquid, it is impossible, owing to the agitation and foaming of the liquid, to always maintain a constant level of the liquid material. This constant change in level results in an irregular immersion of the revolving drum surface, with a consequent variation in the moisture content of the dried product, loss of continuous service, low output and heavy cost of operation.

With our method the drum does not come into contact with the main body of liquid and, therefore, any material can be dried satisfactorily whether it foams in a vacuum or not. It is also to be noticed that as some materials give over their moisture more readily than others, the speed of the drum, and the pressure of steam used in the drum, can be varied to suit the material being treated.

One of the most extensive uses for the "Buflovak" vacuum drum dryer has been in the production of powdered chestnut and hemlock extracts. Formerly, these extracts were put on the market in a liquid state, containing approximately 50 per cent moisture. They were shipped in tank cars. These materials, with this moisture content, can be treated in our machine and dried to a powdered form, having from 5 to 7 per cent moisture content. This dried material can be packed into bags and shipped in this manner to any part of the world. By handling it in this form the market for the material is not only very much widened, but the expense and trouble of tank cars is eliminated, and consequently transportation expenses greatly reduced.

Another important use for this machine has been developed in the recovery of dry sulphite waste from the waste liquors of paper mills. This product, owing to its recovery in a dry state, now brings a handsome profit to the paper mills, and secures another by-product that can be converted to many useful purposes. It further enables the paper mills to comply, actually at a profit, with the laws prohibiting the pollution of streams with sulphite waste.

The approximate capacity of our 5-ft. by 12-ft. vacuum drum dryer on the above mentioned extracts and sulphite waste is 1000 lb. of dry product per hour. The cost of operation is extremely low. We have dried products where the cost, including depreciation and interest on investment, steam, power, labor and incidentals, has not exceeded one-tenth of a cent per pound in reducing a product from a 50 per cent moisture content to a commercially dry product under a 7 per cent moisture content.

Vacuum shelf dryers and vacuum rotary dryers have also been extensively used in the recent chemical development in this country. They can be used to great advantage in drying some of the chemicals derived from coal-tar distillates. This use is in addition to their previously extensive application in the drying of both liquid and solid materials. These dryers are also especially valuable in handling solid materials, the shelf dryer for drying sheet rubber, fruit, albumen, etc., and together with the rotary dryer, is available for use in drying reclaimed rubber, rubber compounds, paints, dyes, extracts, pastes, glue, soap, salts, starch, vegetables, etc. Where the quality of the material is not affected by being tumbled or mixed while drying, or is not of too sticky a nature, the rotary dryer is an ideal apparatus for drying in large quantities.

At the outbreak of the present European war, when the supply of many materials never made in America was cut off, there was a sudden and large demand for chemical equipment, particularly in plants handling the many products produced from coal tar. In order to meet this demand, it was important to first make use of apparatus developed for these purposes in Europe. It was also essential to design new types of apparatus to suit conditions in this country and to make modifications in equipment which had been developed abroad.

The Buffalo Foundry & Machine Company, to its already well established engineering and consulting staffs, at once added a corps of experienced specialists who, with the co-operation of chemical engineers associated with chemical plants, developed machinery to manufacture economically the new products so greatly in demand, and we are to-day supplying apparatus for the manufacture of a large number of these products, such as aniline, acetanilide, anisidine, alpha naphtylamine, alpho-sulfonic acids, amido-naphthol, alpha-naphthol, benzoic acid, benzaldehyde, beta-naphtylamine, beta-naphthol, beta-sulfonic acids, carbolic acid, dinitrobenzol, dinitro-chlorbenzol dimethylaniline, diphenylamine, Gamma acid, H acid, meta-nitraniline, meta-phenylene-diamine, meta-tolulene-diamine, metanilic acid, naphtionic acid, ortho-anisidine, ortho-phenetidine, para-anisidine, para-phenetidine, para-nitraniline, para-phenylene-diamine, para-amidophenol, phenetidine, picric acid, sulphur black, sulfonic acid, Toluidine, xylidine, trinitrotoluol (TNT), nitric acid, caustic soda, etc.

One of the first products we were called upon to produce machinery for was synthetic phenol. The methods generally used in treating sodium benzol sulphonate before fusion with the caustic soda was to take the liquor from the filter presses, evaporate it as far as possible in open pans containing heating coils and then dry the salt before fusion, either by means of heated air or by some other crude method. Seeing the field for improvement here, our laboratory started work on this problem, and it may be interesting to you to know the evolution which finally led up to the present method of operation.

We, of course, easily determined that a vacuum evaporator should be installed for reducing the liquor to a certain density, thus doing away with the open pans. The problem that presented itself, was how best to handle the evaporated liquor. Our engineers and chemists assumed that the vacuum drum dryer would be the ideal machine for treating the liquor as it came from the evaporator, but we found by actual experiment that owing to the peculiar nature of the liquor it was very difficult to secure under a vacuum a good coating on the drying drum.

We next tried the vacuum rotary dryer, but found that this machine formed the product into large cakes or balls. It was impossible to extract the moisture from the interior of these masses without spending considerable time in drying, our object here being, as in all cases, to produce the most economical method for handling a given product. We found that the experience we were having with this product coincided with that which we had had on some other products, which we worked out by using an atmospheric drum dryer for reducing the moisture content to, say, approximately 12 per cent, and then finishing the process in a vacuum rotary dryer. We found that this experiment produced

the desired results and furnished a beautiful sodium benzol sulphonate salt ready for fusing with the caustic soda. Later experiment showed that it was not necessary to reduce the moisture content in the sodium benzol sulphonate to below 12 per cent before fusing with the caustic soda, with the result that the vacuum rotary dryer has been eliminated and the atmospheric drum dryer is used exclusively for handling the liquor as it comes from the evaporator.

We later found that the "Buflokast" atmospheric drum dryer has many uses in chemical plants. The patented successful principles of operation in this dryer are the causes for its exceptional success in this field. It embodies the principles of the "Buflovak" vacuum drum dryer. The same patented automatic device for applying the liquid to the drum produces a uniform coating on the drum, and consequently a uniformly dry product. It is an ideal machine for drying materials that can be dried rapidly and without injury under atmospheric conditions, such as salts of sulfonic acid, sodium naphthalene sulphonate, and other similar products. The machine is continuous in its operation, is a great labor saver, and the finished product produced is uniform, and when desired for fusion is in excellent condition to go direct from the dryer to the fusion operation.

One of the early demands since the European war has been for a reducer for the manufacture of aniline oil. The improvements here which have been made, are the improved sludge unloading device which automatically raises the valve when open, and wedges it in position when closed, the introduction of reversible liner plates, hollow shaft and rake for the introduction of steam when desired, and the jacketed bottom for special cases.

Another development we have made is apparatus for the distilling of beta-naphthol. This consists of a still body, constructed of a special metal, and fitted with a cover in the usual way. The new features of this still is the condensing and receiving system, the condensation being drawn into an air-cooled condenser consisting of a single pipe. This pipe leads into steam jacketed, three-way valve, one of the valve openings attached to the condensing pipe, and each of the other two leads to a receiver. The steam in the jacket prevents the material from solidifying in the shelf, the material on entering the receiver passing between two glasses. By this means the operator can easily determine when it is shut off, and change from one receiver to another.

These receivers are rectangular cast-iron boxes with a door opening the full size at one side. Inside of the receiver is placed a steel box with tapered sides which fits as neatly as possible the full size of the receiver. The beta-naphthol solidifies in this box, which is easily removed and is dumped by taking out the tapered box. In addition to the foregoing, the still is supplied with a large tank in which are placed baffles to collect any material that may pass a receiver. Beyond this tank two smaller receivers are supplied, one for containing the liquid to neutralize the vapors if any should pass this distance from the still. The other receiver is for this liquor in the event that the air current is reversed in the pipe. This allows the liquor to flow from one tank to the other as the case may be. The entire apparatus is evacuated by means of a dry vacuum pump, and the still is heated by a direct fire.

Another of our developments in the manufacture of sulfanilic and naphtionic acid and for reclaiming high-boiling-point solvents from waste is a direct-heated shelf retort, consisting of a chamber, provided with ducts passing from one side through an opening on the opposite side. Between the ducts, and inside of the apparatus, are formed shelves. The one side of this retort is provided with a door opening the full size of same. The retort can be operated either with or without a vacuum. The retort when operated under vacuum is connected with a dry vacuum pump and a condensing system between the pump and retort. The material is placed on the shelves in pans and the hot gases from the furnace in which the chamber is placed passed through the inside of the shelves. The regulation of the temperature on each shelf is made by dampers, which permit more or less of the hot air to pass through the shelf. This type of retort is far more efficient and has a much larger capacity than the previously odd-shaped affairs used for this purpose, and is much more rapid in its operation.

Another improvement that we have made is in the construction of autoclaves for the production of dimethylaniline. It has always been the practice to use an enamel or silicon lining in the autoclave, which has caused more or less trouble due to the checking and cracking and final deterioration of the enamel. This led us to develop an autoclave which uses as a liner a highly acid-resistant cast iron. The difficulty encountered in this construction was that the acid-resisting metal is more or less brittle and would not stand for the high pressure the autoclave works under in the manufacture of dimethylaniline. This led to our adopting the method of backing up the acid-resisting castings with a lead lining.

The rapid expansion of the chemical industry has brought up seriously the question of economical acid recovery plants. In this line one of the ingenious and unique developments has been the patented denitrating apparatus, which has for its purpose the distillation of nitric acid from a mixture of nitric, sulphuric and water. This particular form of construction of the machine enables this nitric to be distilled off at a high strength and reasonably free from lower oxides of nitrogen.

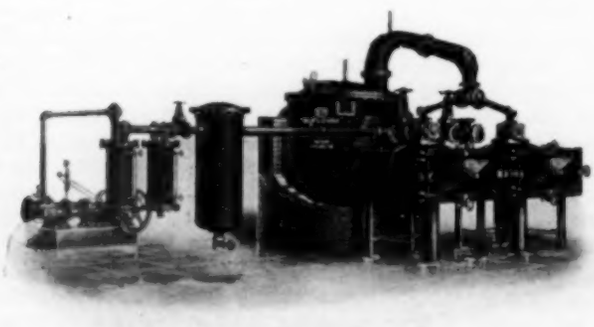


FIG. 2—BETA NAPHTHOL STILL

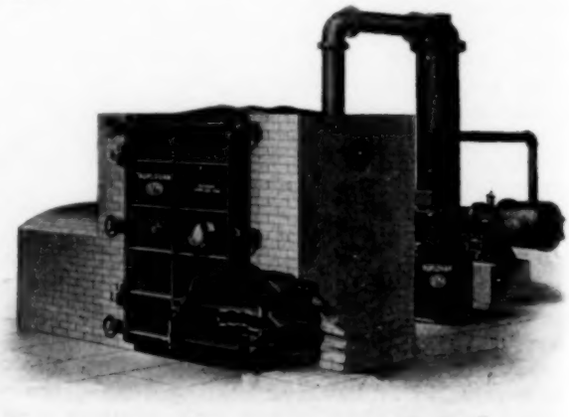


FIG. 3—DIRECT-HEAT SHELF RETORT

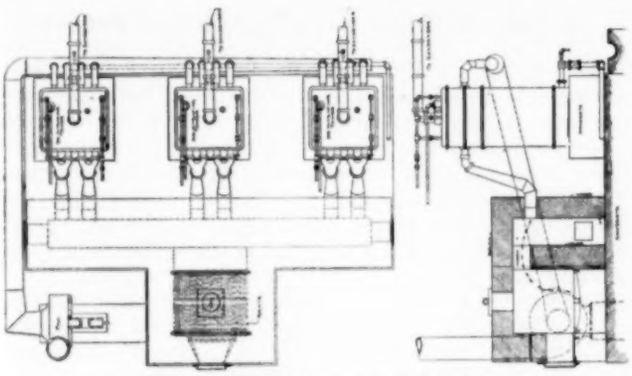


FIG. 4—DENITRATING APPARATUS

The reasons why results can be obtained from this apparatus and not from an ordinary plain still are as follows:

The new type of denitrating apparatus presents a very large heating surface in contact with the acid mixture to be treated. The temperature of that part of the apparatus above the level of the acid mixture cannot by any possibility rise above the temperature of the nitric acid vapors produced in the apparatus. By this means the strongest nitric acid vapors are not decomposed by coming in contact with superheated metal surfaces. Therefore, the very strongest acid, and fairly free from lower oxides of nitrogen, will result.

The distillation of the nitric acid is effected at a much lower temperature than is ordinarily possible. This is done by the injection of air at the bottom of the machine, which keeps the acid mixtures in violent agitation, and the nitric acid held in the mixture is removed most effectively by the sweeping effect of the air. The direct heat from the furnace is drawn through the double U pipe in the apparatus, which are always covered with acid. By this means the greater part of the heat is directly absorbed and the balance of the heat contained in the flue gases after leaving the double U pipes is drawn around, thus giving additional heating surface and giving the greatest degree of efficiency in operation. The distillation of the nitric acid is therefore effected under almost ideal conditions, and by the use of the air the factor of mass action (which has to be considered in an ordinary still when nearly all the acid is distilled off) does not occur in the new type of apparatus. By this I mean that when the ratio of sulphuric acid to nitric acid toward the end of a distillation becomes so great that a very high temperature has to be carried in the still, the nitric evolved must necessarily be weak.

For example, in handling a guncotton displacement system the first run-off of spent acid is, of course, reinforced with nitric and oleum, but the second displacement, which consists of approximately 18 per cent nitric, 60 per cent sulphuric and 22 per cent water, if placed in the ordinary still will only give a nitric acid on distillation of about 78 per cent to 80 per cent HNO_3, and even at that the temperature has to be carried to about 180 to 190 deg. C., and in a fraction of the time taken by the ordinary methods.

It is well known that from guncotton-spent acid, and particularly where oleum is used in making acid mixtures, enormous quantities of sediment will fall down to the bottom of an ordinary still, which is difficult to handle, as it tends to choke the whole system. Now, in the new form of denitrating machine, after six months' work, there is not the slightest indication of sediment forming in the machine, and this can be readily understood, as the acid is kept in violent agitation during the whole time of distillation, which prevents the settling of the mud always occurring in the ordinary still.

As to the kind of acid mixture best suited for this new type of machine, I would state that any acid mixture containing a nitric content above 2 per cent can be readily handled, and the nitrous contained in the acid mixture is to some extent oxidized by the large volume of air passing into the machine.

As air is used in this machine, which, of course, means that it is saturated with nitric acid to an extent determined by the temperature at which the air vapors pass through the condensers, some form of tower is absolutely essential in order to deprive the air of the nitric acid. The best form of tower for this purpose is a small one through which a very small quantity of water is allowed to trickle so that a fairly strong acid can be obtained at the foot of the tower, and no nitric acid allowed to escape at the top. An ordinary form of absorption tower can be used for this purpose and need only be quite small, 5 ft. high by 18 in. in diameter is quite sufficient.

As to the commercial value of this apparatus, as it refers to the handling of waste acid, one may sum this up in the following statements:

A stronger and higher grade of nitric acid can be obtained by the new machine than by any of the older processes.

The fuel efficiency per unit of nitric obtained is exceedingly high.

The capacity of the new machine per unit weight of acid handled is very much higher than with the old type of still.

The space occupied by the new apparatus is only one-sixth that required by the older type of still.

The life of the new type of apparatus is infinitely greater than the old type of still, as with the new form of apparatus only strong acids come in contact with the metal, and that at lower temperatures.

Some improvement has also been made in evaporators for the chemical and other fields which has been of great advantage in the development of chemical plants, which started with a small capacity and later desired to increase their production.

The "Buflovak" evaporator has the advantage that it can be doubled in capacity by merely inserting an additional belt and new tubes. This takes up very little additional floor space and gives 100 per cent more capacity.

Another development, which has met with considerable favor in chemical plants, has been the adaptation of the "Buflokast" crystallizing pan to many uses in the drying and crystallizing of products which tend to be sticky or gummy in the drying process. This crystallizing pan has been very efficient for concentrating and crystallizing material, permitting high temperatures. It has been used heretofore almost exclusively in this country for evaporating and neutralizing liquor of ammonia and nitric acid, and drying and crystallizing the finished product. This pan has also been equipped to operate under vacuum, which provides a means for the drying of sticky materials at low temperatures.

A recent development in equipment for handling acids is the so-called acid-proof or acid-resisting castings, which were first made in England and later in the United States. In the United States we have kept pace with this movement and have manufactured not only small pipes as a substitute for stoneware for conducting acids, but have made various shapes and sizes of retorts. It is only recently that medium sized castings have been made with this metal. On account of the brittleness of the metal the problem from a foundry standpoint is a very difficult one, but advancement has been made, both in the size of the castings and in the shapes of them for acid work. No doubt the next two

or three years will see a considerably greater improvement in the quality and size of this equipment. I believe that as large and difficult castings are now being made in this country, if not more difficult ones, than in Europe. The use of castings made of this metal is bound to greatly increase on account of such castings being superior to enameled equipment and stoneware for many classes of work.

The Buffalo Foundry & Machine Company has for some years had a chemical laboratory and a physical laboratory for work required in the carrying on of its business. We are now erecting a large laboratory building, and will add very materially to the equipment already in use, not only in order to conduct many tests in our experimental dryers and evaporators, but also for research work in organic chemical lines. We expect that there will be a demand for new apparatus to handle the enlarging field of chemical products, and we hope to be able to serve in this development by having a properly equipped laboratory and competent engineering talent to carry on some of the research work.

However, as the old proverb says, "necessity is the mother of invention," it is important, first, to know what is required before apparatus can be designed for meeting new requirements. In the manufacture of chemicals, it is the man in charge of the plant who meets these new problems and who can call upon the research and designing engineer for his services in solving. It is, therefore, important that the chemists in charge of the manufacture of chemical products cooperate with the machinery manufacturers in speeding the advance in the design of machines to meet new conditions. It is true that great secrecy surrounds many of the chemical manufacturing processes in this country, and where publicity would effect the earnings of chemical companies it is wise to avoid undue publicity. But giving due regard to the protecting measures required, I believe it is nevertheless possible for manufacturing chemists to submit many problems to the manufacturers of chemical equipment, which the latter can solve to the benefit of both sides of the industry.

Buffalo, N. Y.

The Youngstown Chemists' Club has been recently organized, and the following officers were elected: President, Mr. Edwin G. Pierce, Consulting Chemist; secretary, Mr. Carl Weesner, Carnegie Steel Co.; treasurer, Mr. H. E. Moyer, Brier Hill Steel Co.

The first regular meeting Dec. 14, was a symposium on the local water situation. The Club is considering plans for a home of its own.

The Schaffer Engineering & Equipment Company, Tiffin, Ohio, has finished an installation of a No. 20 Poidometer with Liquid Measure attachment in one of the plants of the LaClede-Christy Clay Products Company, St. Louis, Mo., and has an order for four more from the same company.

The present installation is handling a mixture of ground fire clay in a predetermined amount, delivering same by actual weight and adding thereto, the right proportion of water, all of this being accomplished automatically and with a decrease in labor cost at this particular station.

Increasing Use of Coke as Boiler Fuel in England.—The London County Council has ordered 8 coke-burning mechanical stokers for the Greenwich power station. These will have a capacity of 100 tons of coke in 24 hours. The economic reasons for burning coke instead of coal and thus saving the valuable by-products incident to coke manufacture, are being increasingly appreciated in England.

A New Electric Zinc Smelting Process

Dr. Charles H. Fulton, of the Case School of Applied Science, Cleveland, Ohio, has been known for some time to work on the development of a new electric-furnace process for zinc smelting, for which various advantages have been claimed. The first authoritative information on this process has now come out through the granting of U. S. patent 1,213,180 (January 23, 1917), to Charles H. Fulton (assigned to David B. Jones, of Chicago).

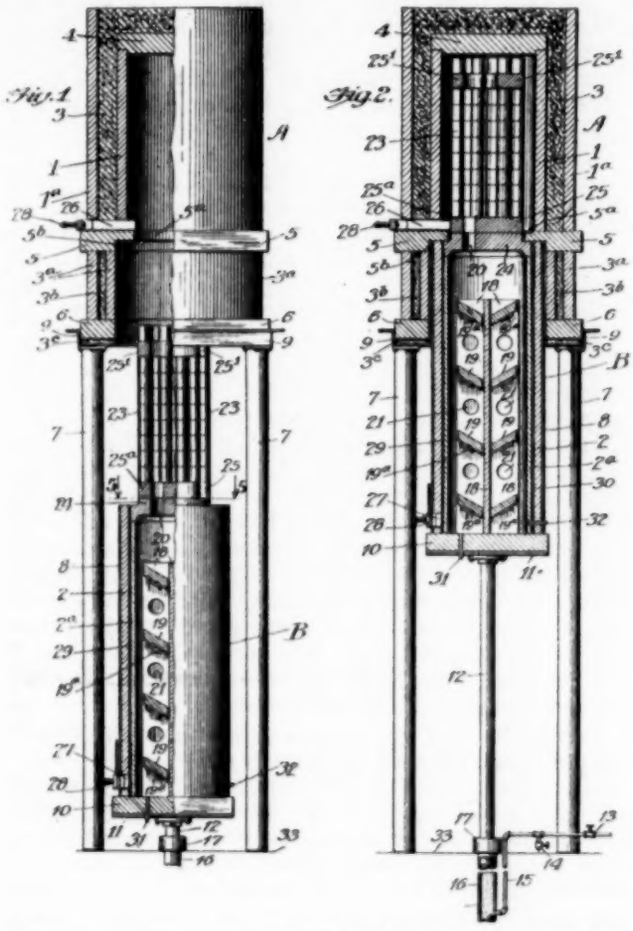
A resistance furnace is used and the charge itself is the resistor, but the novel feature of the Fulton process is that the charge is made up into briquets which preserve their form and volume during distillation. In the closed retort chamber the briquets are placed so as to form a continuous resistor between the electrodes; the heat is developed uniformly within the resistor without local overheating.

The briquets are made up of 50 to 60 per cent by weight of ground and calcined ore, 30 to 40 per cent of pulverized coke, and 10 to 20 per cent of finely ground hard coal-tar pitch. After a uniform mixture of the three constituents has been obtained, the mixture is heated to the melting point of the pitch, which melts and softens in place and thoroughly coats each article of ore and coke. The mixture is then formed into briquets of cylindrical shape in suitable molds, in which they are subjected to a high pressure, upward of 500 pounds to the square inch, to solidify the mixture.

The briquets are next preheated for the purpose of driving off the volatile hydrocarbons of the binder (which would dilute the zinc vapor in the subsequent distillation and interfere with condensation). For this purpose the briquets are subjected to a gradually rising temperature reaching from 400 to 600 deg. C. in a reducing atmosphere (by embedding the briquets in finely crushed coke). It is even advantageous to raise the temperature to 650 or 700 deg. C. in order to convert the briquets into better conductors of the electric current. The structure of the briquets produced in this manner is that of a large number of ore particles embedded in a coke matrix, this matrix being made up of the original coke and the coke left by the distillation of the pitch binder. Such briquets have a specific resistance of 0.03 ohm per cubic inch.

Fig. 1 is a view of the furnace, with the lifting means by which the briquets are lifted into the distillation chamber or retort shown in its lower position, as it would appear either immediately after the distilled briquets have been withdrawn from such chamber or immediately before the undistilled briquets have been raised into it; Fig. 2 is a corresponding view, showing the briquets lifted into position in the distilling chamber. A is the distilling chamber with the vertical columns of briquets 23 and the electrodes 25 and 25′ at their lower and upper ends. B is the condenser.

Figs. 3 and 4 are horizontal cross-sections through the distilling chamber at the points of the lower and upper ends of the briquet columns respectively. In the illustrations there are shown twelve vertical columns of cylindrical briquets 23, constituting a "charge" for the retort A, and as the furnace is designed for use with a three-phase alternating current connection of the Y-type (star type) the columns of briquets are arranged in six pairs. The columns of briquets rest upon the graphite electrodes 25 and 25ª, which in turn rest upon the tile-block or grid 24 which constitutes the closure for the upper end of the condenser B. The three electrodes 25ª (Fig. 3) each support two columns of briquets and are located at equidistant points around



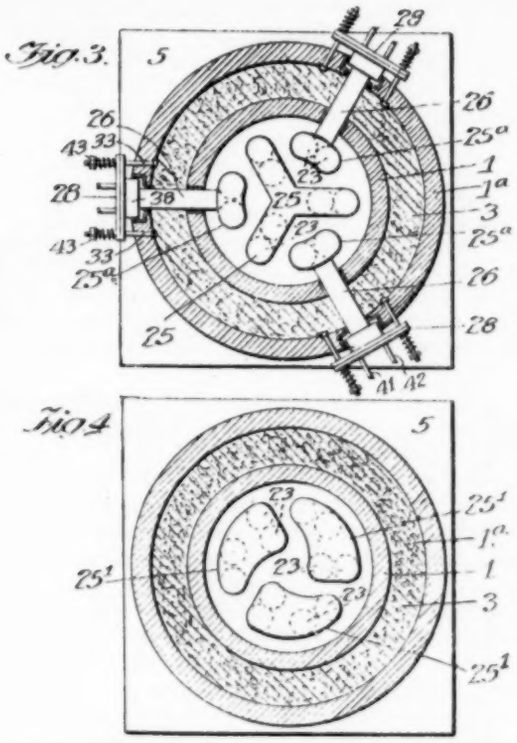
FIGS. 1 AND 2—VERTICAL CROSS-SECTIONS THROUGH DISTILLING CHAMBER A AND CONDENSER B

the block 24 adjacent the periphery of its upwardly projecting circular central portion, while the electrode 25 is a three-armed neutral point electrode, two columns of briquets being supported upon each of its three radial arms, as shown. Current is conveyed to the electrodes 25ª by three graphite electrodes 26.

At the tops of the columns of briquets the adjacent pairs of columns are connected in the manner shown in Fig. 4 by the electrodes 25′, each of which is suitably shaped to rest upon and electrically connect the tops of two adjacent pairs of columns.

If we take, for the purposes of explanation, the current conveyed to the left-hand pair of columns of briquets in Fig. 3 by the left-hand electrode 26 there shown, the current will pass upward through said columns of briquets to the electrode 25′ which rests upon their upper ends (Fig. 4), thence through said electrode to the upper end of the adjacent pair of columns of briquets, thence downwardly through said columns to the radial arm of the electrode 25 upon which said columns rest, being the upper left-hand arm of said electrode in Fig. 3, thence to the neutral point at the center of said electrode. The passage of the current for the other pairs of columns of briquets is similarly all convergent on the neutral point of the electrode 25, which gives the common Y-connection of the alternating three-phase current.

The current is supplied to the distilling chamber from an adjustable-voltage transformer. The amount of current passed through the briquets is preferably at first relatively small, so that the walls 1 of the retort A will be heated rather gradually to about 700 deg. C. or 800 deg. C. by radiation from the briquets. The current may then be rapidly increased and the briquets raised to a distilling temperature. The zinc vapor then freely evolved will fill the retort space and pass down between the electrodes 25 and 25ª and through the openings 20 in the block or grid 24 into the condenser B. By means of carbon resistors in the shell the condenser is kept at a temperature between 500 deg. and 650 deg. C., the higher temperature obtaining near the top and the lower near the bottom. The zinc vapor strikes against the condensing plates 19, and circulates between the same and the walls 18, as well as through the openings 21 and in the annular space 22 surrounding the walls 18. The large surfaces afforded by these parts and the interior walls 2 of the condenser serve to rapidly condense the zinc vapor into liquid zinc, which collects in the bottom of the condenser. The carbon monoxide gas evolved in the distillation of the briquets passes out and burns at the opening 32 in the bottom of the condenser. The liquid zinc is tapped off at the tap 31. When the briquets are completely distilled, which is indicated by the dying down of the flame at the opening 32, the condenser is lowered by means of the hydraulic apparatus into the position shown in Fig. 1, and the briquets then quenched rapidly with a spray of water and removed from the grid 24, a fresh charge put in their place, and the condenser again raised into distilling position and the described operation then repeated.



FIGS. 3 AND 4—HORIZONTAL CROSS-SECTION THROUGH DISTILLING CHAMBER AT BOTTOM AND TOP OF BRIQUET COLUMNS RESPECTIVELY

Ceramic Engineering.—The Department of Ceramic Engineering of the University of Illinois, Urbana, Ill., will issue shortly a new bulletin describing in detail the courses, both graduate and undergraduate, which it offers in ceramic engineering and ceramic chemistry. The bulletin will also contain an illustrated description of the new laboratory and its equipment, and a list of the names and addresses of the graduates of the department since its establishment.

A Method of Determining the Density of Flue Gases*

By James Alex. Smith

Engineers, whether power, metallurgical or manufacturing, can always ascertain the density of the gases within their province, either by chemical analysis or precision weighing. But it is not always essential to know the chemical composition; or the composition may be deducible with sufficient accuracy if the density is known. Then methods of a simpler or more direct character have a use, particularly when it is desired to study cause and effect concurrently, and without any appreciable intervening interval during which the cause might vary.

The purpose of this paper is to describe a mode of determining gas density by gage reading. So far as the writer is aware, the method is new.

General Principles.—The basic theorem is that the densities of gases and their pressures per unit area of base are directly proportional when the gas columns are of equal height. Hence, if a column of air in a vertical tube of known height is displaced by a given gas, the barometric and thermometric conditions remaining constant, the densities are in the simple ratio

$$D = \frac{P \pm P'}{P} \quad . \quad . \quad . \quad . \quad (1)$$

when

D = Density of the given gas referred to air taken as unity,

P = Known air pressure due to column height, and

P′ = Difference (±) of pressure due to gaseous displacement.

Pressure Measurement.—Assume that an accuracy within 1 per cent of the total air pressure due to the vertical or column height is required; in other words, that a pressure due to the air in a column the one-hundredth of the height of the column in the given case must be evaluated. This order of minuteness of magnitude at once contraindicates mechanism subject to friction, and indicates the use of "frictionless" liquid gauges.

Postulating that, without the introduction of undesirable complications, 0.02 in. is the smallest significant difference of level of such a gage, then the relation of that minimum gage space to the minimum correlated gas-tube height (h) is given by the equation

$$h = .02 \text{ in.} \times 100\,x \quad . \quad . \quad . \quad (2)$$

when x is the specific gravity of the gage-liquid referred to *air* as unity. Therefore water, which is about 772 times heavier than air, if used in a simple siphon gage, and under the conditions postulated, requires a complementary gas-tube not less than 0.02 in. × 100 × 772 = 1,544 in. = about 130 ft. in height. Conversely, if the height (h) in inches be given, then the maximum specific gravity of the possible gage-liquid (air, as before, being taken as unity) is determined by the formula

$$x = \frac{h}{2} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Any convenient value may be assigned to h. Let, then, the vertical height of the gas column be 100 in. Then x = specific gravity 50. That is, for such a tube height, a liquid is indicated not more than 50 times heavier than air, or, $\frac{772}{50}$ = 15.44 times lighter than water.

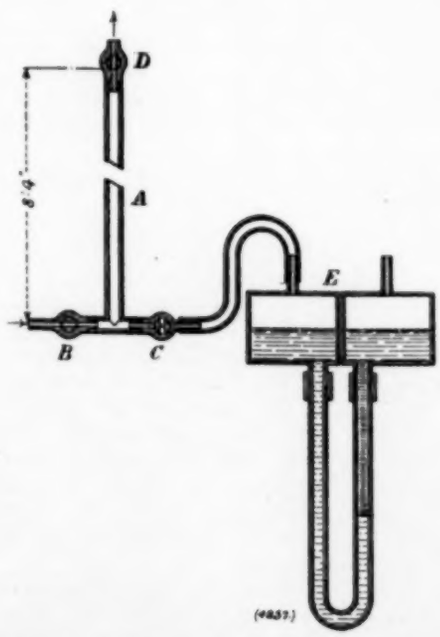
No such light liquid is known; but its equivalent may be attained if two immiscible liquids are caused to partially equilibrate each other in such a manner that the *difference* (which may be made as small as desired) of the specific gravities becomes the measure of the equivalent specific gravity of the liquid system as a whole.

A gage on the differential principle, capable of readily dealing with gas pressures of the small magnitude in question, has already been described by the author in the "Proceedings" for November, 1909, vol. x, page 155, under the title, "A Simple, Sensitive, Two-Liquid Differential Gage for Measuring Small Pressures."

Gas Tube.—The gas tube is very simple. In the example illustrated it consists of a piece of ⅛-in. wrought-iron gas-barrel, A, 100 in. in height. At the bottom two stopcocks, B, C, permit alternative connection to a gas-source or to a gage, E. To check diffusion the passage through the latter cock should be reduced to a pinhole. At the top a third cock, D, opening into the air, permits the tube to be gas-flushed and filled, and when the main passage is closed continues the connection by a minute by-pass large enough to preclude any possible barometric difference of pressure between the gas inside and the air outside the tube, yet so small that diffusion is negligibly slow. The surface of the liquid in the gage cistern and the bottom of the gas tube must be approximately at the same level.

Calibration.—If the gage constants are unknown, a simple, comprehensive calibration covering all the factors can be effected thus: All parts being filled with air, adjust the gage to zero. Then displace the air in the tube with any easily generated or procured gas of known density, for instance CO_2, the specific gravity of which is 1.524. Then the pressure upon unit of base of 100 in. vertical of CO_2 is equal to the pressure of 100 × 1.524 = 152.4 in. of air. Therefore, the consequent liquid displacement due to the displacement of the air by gas is equivalent to that which would be caused by an air pressure of 152.4 — 100.0 = 52.4 in. The scale can be graduated or interpreted accordingly.

Corrections.—When relativity only is required, corrections may be dispensed with. The case of the im-



A—Gas tube. B—Inlet gas cock. C—Gage cock. D—Outlet gas cock. E—Differential gage.

NOTE.—The barometric equalizing vent (at D) is not shown. It consists of a piece of clockmaker's "bushing wire," 1 in. long and 1/80-in. bore.

* A paper read before the Victorian Institute of Engineers and published in London *Engineering*.

mediate effect of draught volume variation upon chimney-gas density is an example.

But if absolute readings are required, and if the barometric and thermometric conditions differ from those which may have been assigned in respect to P (formula 1), and upon which the value of the gage divisions is computed, then a corrected value P″ must be substituted for observed P′ in formula (1); then

$$P'' = \frac{(461 + t)\ 29.92 \times P'}{461 \times b} = \frac{(461 + t) \times P'}{15.41 \times b} \qquad (4)$$

when

t = Observed temperature on Fahrenheit scale,
b = Observed barometric pressure in inches,
P′ = Observed pressure due to gas displacement, and
P″ = Corrected value of observed displacement pressure.

Strictly, a further correction should be made to compensate for the variation in the gas system volume, due to the movement of the liquid in the gage. Usually, however, this amount is so small that it may be neglected in practice.

Scales.—The actual graduations may be in any convenient terms, *i.e.*, density or specific gravity, percentages, or direct evaluations of the major object of the test.

Variants.—(i) The mode is equally applicable in the case of density change due to chemical reaction other than combustion.

(ii) In the case of inconveniently high tubes, all adjustments may be brought within operative reach by constructing the tubes as an inverted ∩ providing that the minute equalizing vent must then be placed at the vertex, and must remain permanently open.

(iii) A gas tube within a chimney and extending to its full height affords a means of ascertaining the density of the chimney gases at the *mean* temperature within the whole stack. From this may be deduced the potential ascensional power of the gases, a result not given by the ordinary draught gages, which show the utilized value only.

(iv) Obviously portability can be attained by constructing the tube in screwed sections.

(v) Photographic continuous records can be attained by the use of any of the well-known devices. This implies a constant passage of gas, therefore precautions must be taken against the vitiation of the results by the introduction of extraneous pressure head, either by periodically cutting off the gas supply, or by making the inlet very small in comparison with a relatively large outlet permanently open. Necessarily there will be a lag in the records in respect to time.

Synopsis of Recent Metallurgical and Chemical Literature

Rubber

Vulcanization of Rubber.—The researches of the eminent Russian chemist I. I. OSTROMYSLENSKI, originally published in the Journal of the Russian Physico-Chemical Society, were translated for the *India Rubber Journal* (England) and published in its Sept. 30, 1916, issue. They have been republished in the *India Rubber World* for Nov. 1, 1916. The papers describe a most interesting set of researches on the vulcanization of rubber without the use of compounds containing sulphur. Up until the present investigations were made no method of vulcanizing caoutchouc was known in which a sulphur free organic or mineral compound was used. The chemical and physical theories of vulcanization suggested a whole series of such compounds, and Mr. Ostromyslenski has succeeded in discovering by the application of physical chemistry two new methods for hot vulcanization. From a consideration of the properties of sulphur in oxidizing ethylenes, melting point, vapor pressure at the temperature of vulcanization, and other properties, substances were found having similar properties which would effect the vulcanization of rubber. Among these is 1:3:5 trinitrobenzene, and also other nitro-compounds, perbenzoic acid, gaseous oxygen, and various peroxides, per acids, etc. The work of Ostromyslenski is a most interesting and valuable contribution to the chemical industry, and a study of the chemical principles involved is very interesting. His work leads to a more rational explanation of the mechanism of vulcanization.

Natural Gas

Conservation of Natural Gas in Oil Fields.—A description of a process for the prevention of natural gas waste in oil fields is given in Bulletin 134, recently issued by the Bureau of Mines. The authors are JAMES O. LEWIS and WILLIAM F. MCMURRAY.

"One of the most shameful wastes of this country's natural resources has been that of natural gas in the oil fields," the authors state. "This waste has been occasioned very largely by not having efficient and cheap methods of controlling the gas, nor adequate laws and regulations to enforce the control.

"Soon after the establishment of the Bureau of Mines investigations were started with the view of finding means of lessening this waste. In 1913 engineers of the Bureau of Mines were sent to Oklahoma to investigate the waste and to recommend methods for its prevention. These engineers recommend the mud-laden fluid system, which had been previously used in Texas and California, and demonstrated that the method was equally applicable to the conservation of gas in the Mid-Continent and Eastern fields."

Bulletin 134 consists of three parts. The first part covers the theory of the process and the manner in which it is used, so that the operator will understand the principles and be able to use the process even though he has had no previous experience with it. There are numerous figures illustrating apparatus and showing conditions under which the process has been used. The bulletin shows how mud-laden fluid may be used advantageously to conserve the oil and gas, shut off water, overcome high gas pressures, prevent fires and accidents, drill through loose and caving formations, save casing, and to protect casing against corrosive waters. It tells how many sources of trouble, danger and expense may be eliminated. The latest apparatus and methods, including the circulator method of drilling with cable tools, are given.

In the second part are accounts of many demonstrations of difficult cases in the Mid-Continent field. In many instances these demonstrations were made after all other methods had failed. Demonstrations were made in overcoming high pressures, in saving casing, in protecting formations, and in overcoming other difficulties. The method has now been used in several hundred cases in the Mid-Continent field. It has been the means of conserving an enormous quantity of gas, and has made possible the practical enforcement of conservation by the State and Federal authorities in Oklahoma.

In the third part are given copies of the oil and gas conservation laws of Oklahoma, and the regulations governing oil and gas operations on restricted Indian lands, which are under the supervision of the Federal government. The main purpose of this paper is to demonstrate practical means for conserving oil and gas, and these laws and regulations are included to show what technical principles should be embodied in laws and regulations to enforce conservation.

Copper

Metallurgical Operations at the Chile Exploration Co.—C. A. Rose, in the August, 1916, number of the *Teniente Topics*, pages 19 to 23, gives a very interesting description of the metallurgical work done at Chuquicamata, Chile, by the above-named company. The process used was worked out at Perth Amboy on a 15-ton plant basis by E. A. Cappelen Smith, and it is claimed by the author that the process as now used on a 10,000-ton scale works as satisfactorily as on the small scale. The commercial copper ores treated are chalcocite, covellite, brochantite, chalcantite, kroenkite, atacamite, chalcopyrite, bornite and enargite.

The plant as it is now operated may be divided into the following units: crushing plant, leaching plant, dechloridizing plant, pumphouse, electrolytic tank house, smelting and melting plant. The crushing plant consists of two No. 10 McCully gyratory crushers, two 48-in. Symons disc crushers and eight 54 x 20-in. high-speed rolls. Construction is now under way for the installation of two 84 x 60-in. Superior jaw crushers to relieve the overburden which was, up to date, thrown on the original crushing plant. Additional grizzlies and screening appliances are also being installed in order to by-pass the fine material around each crusher and to return to the rolls the oversize from the final product delivered to the leaching plant. It is expected that with these improvements the full tonnage of 10,000 tons of ½-in. material will be supplied to the leaching department.

In the leaching plant are six leaching tanks, each 150 ft. long, 110 ft. wide and 16 ft. high, and nine solution tanks set on a somewhat higher level. All tanks are set end to end and are built of reinforced concrete line with 1 to 1¼ in. of mastic asphalt. The mastic consists of one part of Trinidad asphalt and four parts of sand. After melting the asphalt, it is mixed with the sand in a Gulich asphalt mixer, and after thorough incorporation is poured, while still hot, between steel forms and the sides of the tanks. The steel forms are built in sections as the lining of the tanks is cast. On the sides of the vats the mastic is kept in place by means of expanded metal laths embedded in the mastic and anchored to the sides of the tanks.

The false bottoms of the leaching tanks are constructed of 6 x 6-in. timbers, laid 10 in. apart on the floor of the tank. Above these and laid crosswise are placed planks 2 x 6 in. and 3 in. apart. This structure is then covered with cocoa matting, which in turn is covered by 2 x 6-in. planks, ½ in. apart. On starting operations a 1-ft. layer of coarse material is spread over the false bottom. On discharging the tank this bottom layer is left intact and forms a very satisfactory sand filter. Eight 6-in. outlet pipes are distributed evenly around the bottom of each tank. These pipes unite in a 15-in. main leading to the pumphouse. The pipes conducting acid solutions are lead-lined iron pipes, joined with standard flanges and rubber gaskets, which take up the expansion and contraction due to any temperature changes in the weather conditions.

In the process of leaching, a portion of the last solution drawn from the tanks is removed for complete deposition of the copper. This amount is so calculated as to compensate for the increase in total volume of the solution, due to the addition of more water as a last wash on the ore than is discharged as moisture in the residue, and also removes from the system continually the impurities that are introduced by the ore and accumulate in the solution. After freeing this portion of the solution from copper, it is discarded. The essential impurities are the sulphates of sodium, potassium and magnesium. When these have accumulated to the extent of 150 grams of sodium sulphate, 10 grams of potassium sulphate and 65 grams of magnesium sulphate per liter, the discarded solution in each cycle removes the same quantity of these salts as is introduced into the system by the quantity of ore leached. Iron sulphate does not seem to accumulate to any great extent in the process. Any possible chlorine, which might enter the solution, is previously taken care of in the dechloridizing plant.

After filling a tank with ore, the first solution is introduced by upward percolation, preventing thus the fine particles of ore to drop on the bottom, which would be the case if the solution were applied from the top. After allowing this solution to remain in contact with the ore for 36 to 48 hours, it is drawn off and replaced by downward percolating new solution.

The solution withdrawn for the precipitation of the copper contains about 6 per cent of the total copper content, extracted from the ore. The copper thus obtained is either cast into soluble anodes and used in the electrolytic tanks for making starting sheets or is delivered to the dechloridizing drums for the precipitation of cuprous chloride. The acid lost in the discarded liquor and also in the removal of the acid element chlorine in the dechloridizing plant is nearly equivalent to that gained from the copper sulphates chalcantite and brochantite, provided the ore has a copper content not less than 2 per cent and does not exceed 0.2 per cent chlorine. However, an acid plant is in connection with the works, so as to supply any excess acid if needed. This is simply a precaution and not a necessity at present.

The dechloridizing plant comprises 22 tube-mills 30 ft. long with an internal diameter of 4 ft. They are built of ½-in. steel shells lined with thin lead and with an inside shell of earthenware set in asphalt mastic. They are filled nearly half full with granulated copper and revolve at 8 r.p.m. Gravity flow conducts the solution from the solution tanks to the dechloridizing plant, where it is divided to supply the 22 tube-mills. The chlorine on its passage through the mills forms cuprous chlorid, which remains in the solution finely divided and is carried on by the stream of solution into seven Dorr thickeners. The pulp is dewatered in these thickeners, so that only 50 per cent moisture remains in the product. This product is then delivered to an Oliver filter and the cake thus obtained is sent to the smelter, where it is mixed with limestone and coke and smelted in a blast furnace. The furnace products obtained are black copper and calcium-chloride slag.

Various treatments of cuprous chloride have been tried, such as smelting, electrolysis and cementation, and it has been decided that the cementation was most beneficial under the circumstances of the operation of the plant. This decision is due to the amount of cement copper required in the dechloridizing mills. The cuprous chloride will be dissolved in brine solution and the copper precipitated on scrap iron. The amount of iron used will be approximately half of that used in the ordinary cement copper processes, due to the fact that the copper is present in the cuprous and not in the cupric form. Part of the ferrous chloride formed in the process will be used for dissolving more cuprous chloride instead of using salt.

The clear solution from the thickening tanks is pumped to a large, asphalt-lined concrete storage tank of 1815 cu.m. capacity. From here the solution is conducted to the electrolytic tank house by means of

gravity. The novel features of this part of the process consist in the use of magnetite anodes, asphalt-lined cement electrolytic tanks and launders, the use of large-sized cathodes (3 ft. x 4 ft.) and the cascading of 16 tanks in one solution circuit. Since the outbreak of the war in Europe the magnetite electrodes have been replaced by such made of duriron, as it was impossible to produce the fused magnetite electrodes locally or in the United States, Germany being the only place where electrodes of this type could be purchased. Duriron electrodes answer the purpose fairly well, resisting the dissolving action satisfactorily, but not as well as the fused magnetite. They surpass the magnetite electrodes in strength, but have a much higher over-voltage, which is a decided disadvantage. Duriron electrodes require about 15 per cent more energy than do magnetite electrodes for the deposition of the same amount of copper. This excess energy goes into heat, and at times this heat becomes so high as to soften the mastic lining of the tanks.

The purity of the copper produced is approximately 100.5 to 101 per cent Matthiessen's Standard, being somewhat higher than that produced in American electrolytic refining practice.

Gallium

Electrolysis of Gallium Solutions.—A contribution from the Physical and Chemical Laboratories of Yale University on the production of gallium "trees" is given by HORACE S. UHLER and PHILIP E. BROWNING in the American Journal of Science for November, 1916.

During the process of separating metallic gallium from an alkaline solution by electrolysis it was noticed that black coral-like deposits sometimes formed around the cathode instead of the bright liquid globules which were expected.

The electrolyte used was obtained in the following manner: Leady residues were shaved into small pieces with an ordinary iron ice-plane and dissolved in a solution made from equal volumes of water and strong nitric acid. On cooling, most of the lead crystallized out as the nitrate. Concentrated sulphuric acid was then added to the filtrate and the resulting liquid was evaporated nearly to dryness. The insoluble lead sulphate was removed by filtration after the addition of water. Silver was next precipitated as the chloride by treating the filtrate with hydrochloric acid. By adding an excess of ammonia to the filtrate the hydroxides of gallium and indium were thrown down while most of the copper and zinc compounds were kept in solution. When working with large masses of material it was found necessary to repeat the last operation in order to effect a satisfactory purification of the hydroxides of gallium and indium. Finally, these hydroxides were separated from each other by taking advantage of the facts that indium hydroxide is insoluble in a solution of sodium hydroxide, whereas gallium hydroxide is readily soluble in an excess of caustic soda. The filtrate thus obtained constituted the electrolyte used in the cells. Each step was checked spectroscopically and found to produce satisfactory and efficient separations.

The electrolytic cells consisted of the following assemblage of very simple parts. The vessel containing the liquid was an ordinary glass crystallizing dish 10 cm. in diameter and 6.3 cm. deep. The anode was a thin rectangular sheet of platinum foil, the edges of the submerged portion being 5.5 cm. horizontally and 3.5 cm. vertically. The cathode consisted of a platinum wire sealed into a glass tube with about 2 mm. projecting at the lower end.

The current used was 0.28 ampere. The trees were formed at about 0 deg. C. and the cell was cooled with ice. The gallium trees closely resembled certain arborescent forms of native copper.

Recent Metallurgical and Chemical Patents

Iron and Steel

Open-Hearth Steel Process.—A process for the manufacture of steel by the basic open-hearth process is patented by ALFRED E. DAVIES of Bilston, England. The process consists in coating the bottom and sides of the basic lined bath of the furnace with a special slag, after the metal of a previous charge has been tapped out. The method as used in practice is given as follows:

"Assume that there is in the furnace a molten charge of metal and slag which has been partially worked in the usual way until the bulk of the silicon and phosphorus in the metal has been removed, the slag is then tapped off by tilting the furnace and further additions of lime, iron ore and oxids are made to the furnace, in order to remove the last traces of impurities, thus forming in the second part of the process the rich slag above mentioned, which it is intended to retain in the furnace for the purpose of coating the lining. The metal is tapped off when finished without allowing the slag to run out, and the slag is further enriched and thickened by lime and metallic oxid additions and the furnace tilted repeatedly as above described in order to coat the enriched and thickened slag on the bottom and sides of the furnace lining ready for the next charge of molten pig iron, which is then poured in and a reaction commences which removes the bulk of the impurities, this bringing us to the point which the description of this process started." (1,198,827, Sept. 19, 1916.)

Process of Breaking Steel Bars.—A novel process of breaking steel bars is patented by PIERRE V. L. BELLANGER of Paris, France. At the point in the bar where it is to be broken the bar is heated with an oxidizing blow-pipe flame. The metal becomes brittle at that point and, the bar being placed between two supports, is broken by pressure or blow on the opposite side to which the heating has been done. A flame temperature of about 700 deg. C. is used. It is claimed that the breaking of steel bars can be easily and quickly accomplished by this method. (1,201,137, Oct. 10, 1916.)

Reversing Regenerator-Furnaces.—A flue and valve arrangement for reversing regenerator furnaces is patented by LUTHER L. KNOX, of Avalon, Pa. (assigned to the Knox Pressed and Welded Steel Company of Pittsburgh, Pa.). The claim is as follows: "In a flue and valve arrangement for regenerative furnaces, the combination of air and gas regenerators, a stack flue running transversely of the regenerators, a continuous port connecting each of the regenerators with said stack flue, said ports being at the same level as the stack flue and all opening directly into the same side of said flue, each port having an admission valve in its upper wall, and each port also having a vertically movable damper between said valve and the stack flue; substantially as described." (1,203,748, Nov. 7, 1916.)

Welding Compound—A compound to be used for welding iron and steel is patented by CHARLES W. PHELPS of Coupeville, Wash. The compound consists of nine parts pulverized "volcanic ash" and one part common salt. The metals to be welded are heated to cherry red, coated with the compound and the metals heated to a white heat, when hammering is applied. (1,199,020, Sept. 19, 1916.)

Tool-Steel Alloys.—RICHARD H. PATCH and RADCLYFFE FURNESS, of the Midvale Steel Company, patent a non-deforming tool-steel particularly adapted for dies, taps, reamers, and cutting tools for lathes and planers; it contains 79 per cent steel, 19.5 per cent chromium, and 1.35 per cent carbon. (1,206,902, Dec. 5, 1916.)

A partial substitution of cobalt for tungsten with very beneficial effects in tungsten-chrome steels is the predominating feature of another patent of the same inventors. A preferred composition is chromium 4 per cent, tungsten 13.5, vanadium 1.5, cobalt 15, iron 65, carbon 0.65. (1,206,834, Dec. 5, 1916.)

A third patent of the same inventors refers to the fact that by the addition to steel containing less than 1 per cent of carbon, of certain proportions of molybdenum, chromium and cobalt, the alloy becomes easier to forge, and less subject to sudden inexplainable physical effects; it also performs much more uniformly as cutting tool than do the known molybdenum tool steels. A typical composition is 4.0 per cent chromium, 8.0 molybdenum, 1.5 vanadium, 5.0 cobalt. (1,206,833, Dec. 5, 1916.)

Preparing Iron for Castings.—A patent of WILLIAM G. KRANZ, of the National Malleable Castings Company, relates to the treatment of iron intended to be made into castings, so as to overcome the difficulties resulting from the presence of relatively high carbon, manganese and silicon. The process is well indicated by the fourth claim which reads as follows: "The process of preparing iron for castings which consists in melting iron in a melting furnace, tapping a portion of such molten iron from said furnace and substantially removing its carbon in a Bessemer converter, adding said molten decarbonized metal to a larger portion of the molten iron from said melting furnace whereby the carbon in the combined charge is reduced and equalized, but remains above 1.50 of carbon, and finally treating the combined charge in a refining furnace without further substantial reduction of carbon." (1,206,861, Dec. 5, 1916.)

Manufacture of Iron and Steel.—A process of controlling the carbon content of iron and steel is patented by BRUCE FORD of Philadelphia, Pa. The process consists in supercarburizing molten iron in a Bessemer converter by alternately passing through the iron a hydrocarbon gas and air through separate valves. This carburized iron is then added to decarburized iron in another converter and the final product is obtained. The ultimate carbon content is determined by the amount of supercarburized iron added. As this latter iron has practically always the same carbon content, no chemical analysis is stated to be necessary. (1,205,611, Nov. 21, 1916.)

Titanium

Titanic Oxide.—LOUIS E. BARTON of Niagara Falls has patented a method of obtaining titanic oxide from ilmenite ores. The patent, which is assigned to the Titanium Alloy Manufacturing Company of Niagara Falls, relates to methods described in previous patents Nos. 1,106,409 and 1,106,410, dated Aug. 11, 1914, and No. 1,171,542, dated Feb. 15, 1916, granted to Mr. Barton and AUGUSTE J. ROSSI. These previous patents refer to a process in which the ilmenite ores were melted with an alkali sulphide, followed by lixiviation with water. The mixture was then heated in a bath of dilute sulphuric or hydrochloric acid, which dissolved out everything but the titanic oxide. The objection to the process was the production of hydrogen sulphide from the acid and ferrous sulphide. The present patent proposes to avoid this by the use of chlorine in lixiviation instead of acids. (1,201,541, Oct. 17, 1916.)

Electric Furnaces

Electric-Furnace Control Apparatus.—Apparatus for controlling electric furnaces, particularly arc furnaces, by connecting the electrodes or electrodes with a mechanism actuated by an electric motor is patented by JOHN A. SEEDE of Schenectady, N. Y., assigned to the General Electric Company. The motor is controlled through relays by a circuit-closing magnet responsive to variations of power in the furnace circuit. A switch is also provided for automatically disconnecting the control apparatus, thereby stopping the motor, when the voltage of the furnace supply current falls below the value to which the apparatus is adjusted. (1,206,603, Nov. 28, 1916.)

Hydrometallurgy

Wet Ore Extraction Process.—CHARLES S. BRADLEY of New York has patented an extraction process which is described especially in connection with copper ores containing iron and aluminium which it is desired to eliminate. The finely divided ore is first heated and the dust and fumes passed into an absorber. Both the roasted ore and the products from the dust and fumes absorber are then conveyed to a solution drum where the sulphates are converted into chlorides by the action of calcium chloride solution. The solution is then filtered to remove the gangue material and treated in another drum with calcium carbonate, which precipitates the high valency copper compounds (cupric chloride) and the iron and aluminium. The solution is filtered and the filtrate containing cuprous chloride and zinc chloride is treated with calcium oxide to recover the copper and zinc. The precipitates of cupric, iron and aluminium compounds are returned to the process ahead of the solution apparatus in order to furnish enough iron to insure all of the copper being extracted from the ore, as the iron will not go into solution until all the copper is dissolved. A further object of returning the high valency compounds is that they unite readily with sulphuric and sulphurous acids and form a certain amount of cuprous copper, thus making the process a cyclic one with continual withdrawal of cuprous solution. (1,204,932, Nov. 14, 1916.)

Oxygen Manufacturing Company Expanding Its Operations

The great increase in the demand for oxygen and acetylene gases for welding and cutting is manifested in the rapid growth of the latest company in this field. The Air Reduction Company, which was organized early in 1916 for the manufacture of oxygen and nitrogen from the air by the Claude process, now has nine plants in operation and contemplates putting a new one in operation every five weeks. A short account of the company was given in our issue of June 15, 1916, page 715. The Claude process is used by the American Cyanamid Company in Canada, and was described in our Vol. XIII, pages 187 and 312 (1913).

The company had at the start a contract with L'Air Liquide Societé of Paris for rights to the Claude process for the manufacture of oxygen and nitrogen from the air. Complete equipment for four plants was to have been furnished with the contract to the American company, but the French Government took three of them because of the need of their products for war purposes. As soon as this situation became known to President Birge of the Air Reduction Company, he obtained control of the Superior Oxygen Company, which was using a somewhat similar process.

The principal plants are in Brooklyn, Chicago, Phila-

delphia, Buffalo, Pittsburgh, Defiance and St. Louis. Other plants or warehouses of the company are in the Bronx, New York City, Jersey City, Passaic, Paterson, Chicago Heights, Davenport, Grand Rapids, Joliet, Milwaukee, Peoria, Fort Wayne, Louisville, Toledo, Dayton, Baltimore, Boston, Detroit and Cleveland. The largest Claude oxygen plant in America is in Philadelphia. The company has also taken over one of the largest companies engaged in the production of acetylene, so that it will be able to furnish both the oxygen and the acetylene gases, together with a full line of equipment such as cutting and welding torches. Further, the company has made plans for the production of calcium carbide on a large scale, and for the production of several distinct lines of nitrogenous products both for use as fertilizer and chemical work. One of the most recent efforts of the company has been an educational campaign for demonstrating the uses of the oxy-acetylene torch in trade schools, manual training schools and technical institutes.

The capital stock of the company has been increased from $4,500,000 to $12,000,000.

An Apparatus for Locating Thermal Transformation Points

The more stringent requirements of designers of automobiles, aeroplanes and other machinery have caused more attention to be given to the proper heat treatment of steel and other metals. The strength, hardness, ductility and toughness of steel depend almost as much upon the temperatures at which it is worked, hardened, annealed and tempered as upon its chemical composition. Unless the temperatures are known accurately and with certainty, these qualities cannot be depended upon.

An apparatus for locating critical, recalescence and decalescence points, embodying the approved neutral-body method has been developed by the Leeds & Northrup Company, of Philadelphia, Pa. The method consists essentially in heating a small sample of the metal in contact with a larger neutral body and simultaneously measuring the temperature of the sample by a thermocouple and the temperature difference between the sample and the neutral body by a difference thermocouple while the furnace is being slowly heated and cooled. The apparatus plots these two quantities as co-ordinates upon a rectangular chart and the temperatures at which the various transformations occur are easily indicated in an unmistakable manner by rapid increases in the temperature difference between the sample and the neutral body. For example, at the Ac_1 point, due to the solution of carbon on heating, the temperature of the sample lags markedly behind that of the neutral body.

The thermocouple used for measuring the difference between sample temperature and neutral body temperatur is composed of two pieces of platinum joined by a short piece of platinum-iridium alloy. One of the junctions of the couple is in contact with the sample and the other in contact with the neutral body. The platinum-iridium couple develops a high electromotive force, which changes with temperature at a nearly uniform rate and is therefore well adapted for the purpose.

For indicating the changes in the electromotive force due to these transient differences in temperature between sample and sample holder a sensitive reflecting galvanometer is employed.

For measuring the temperature of the sample a platinum, platinum-rhodium thermocouple is employed in connection with a potentiometer.

In order to eliminate the labor and the possibilities of error involved in reading off the temperatures and temperature difference simultaneously from two different instruments, noting down the figures and subsequently constructing a curve, a transformation point indicator, which constructs its own graphical chart has been developed.

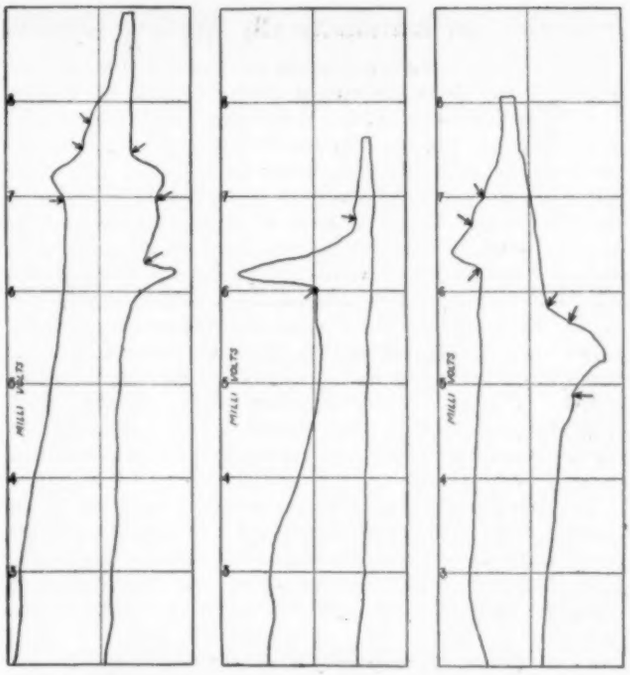


FIG. 1—TRANSFORMATION POINT CURVES FOR LOW-CARBON CHROME VANADIUM STEEL, (LEFT), HIGH-CARBON NICKEL STEEL, (CENTER), AND LOW-CARBON NICKEL STEEL (RIGHT)

The paper upon which the chart is to be made is mounted upon a drum, which also carries the potentiometer slide wire. Bearing upon this drum is a pen. As the drum is revolved to keep the potentiometer in balance, the pen automatically records the corresponding electromotive forces, or temperatures, upon the paper.

The pen, together with a semi-transparent target, is mounted upon a carriage and this carriage can be made to travel parallel to the axis of the drum by rotating a worm shaft. The operator making the curve moves this carriage in such a way as to keep the spotlight from the galvanometer connected to the difference couple always on the semi-transparent target. By so doing the pen is caused to move back or forth across the record whenever the difference in temperature between sample and neutral body changes.

Representative transformation point curves obtained with the apparatus are shown in Fig. 1.

Opening of Bureau of Mines Building in Washington.—Invitations were issued to 1500 mining and metallurgical men of the Northwest to attend a smoker at the Bureau of Mines Building on the campus of the University of Washington, Jan. 12. The smoker marked the formal opening of the Federal mining and metallurgical experiment station in this building. Dorsey A. Lyon, head of the station, spoke on "The Purpose of the Station," and Robert F. McElvenny, superintendent of the Tacoma smelter, spoke on "The Metallurgical Situation in the Northwest." Music, boxing, wrestling and Japanese fencing were provided for the amusement of the gathering and a most enjoyable time was had.

A Device for Automatically Testing Liquids

A device for testing liquids continuously and automatically has been developed and patented by Walter C. Raddant of Elia, Cuba. It is being used successfully in testing for sugar in boiler feed water. A sectional view of the apparatus is shown in Fig. 1. The glass tube with graduations shown at the left in the center of the two larger tubes is used as a mixing tube. The larger outlet at the top of this tube is an inlet pipe, and the smaller one a vent pipe. The container at the left is used for holding an indicator and the container at the right holds acid. The containers and the mixing tubes have spring valves, the containers emptying into the mixing tube and the mixing tube having a bottom outlet. The electrically operated device at the right, consisting of a clock and electromagnet, actuates the cords connected to the plug cocks of the containers and mixing tube.

In operation the liquid to be tested is supplied to the mixing tube. At a predetermined moment the minute hand will make contact with the first screw. This energizes the right-hand electromagnet, exerting a pull on the cable and the opening valve of the container on the

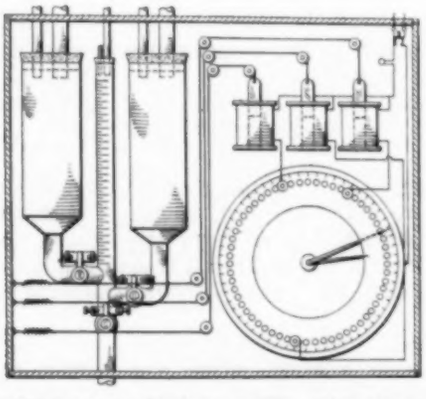


FIG. 1—VERTICAL SECTIONAL VIEW SHOWING ARRANGEMENT OF PARTS OF LIQUID TESTING DEVICE

left. This permits some of the chemical indicator to flow from the container to the mixing chamber. After a predetermined interval of time has elapsed the hand reaches the next contact screw, where the foregoing operation is repeated and the container on the right opens. When the hand reaches the third contact screw the operation is again repeated, the bottom valve opening. It is pointed out that the valves only remain open while the minute hand is in contact with the screws, the valves immediately closing by virtue of their respective retractile springs. However, the bottom valve remains open a sufficient time to permit all of the contents of the tube to flow through the outlet and permitting some of the incoming liquid to wash the tube before the valve closes.

It would seem possible to apply the idea to any number of containers and mixing tubes, provided the action of the plug cocks could be made positive enough to give the desired proportions of reagents.

Society of Glass Technology Formed in England.—At a meeting held at Sheffield University on November 9th a society was formed to represent the glass manufacturing interests and to be known as the Society of Glass Technology. It will be a national society and will hold meetings at various places. Mr. W. F. J. Wood was elected President for the coming year, and Dr. W. E. S. Turner, of the University, Sheffield, secretary.

Personal

Mr. **J. R. Baylis** has been appointed bacteriologist of the Montebello filtration plant, of Baltimore. He was formerly chemist and manager of the Jackson, Miss., waterworks and filtration plant.

Mr. **George M. Berry,** president of the Syracuse Section of the American Chemical Society and chief chemist of the Halcomb Steel Company, Syracuse, N. Y., since its organization in 1905, has been secured by Syracuse University to give a special course of lectures on metallurgy in the College of Applied Science. These lectures will cover the metallurgy of the non-ferrous metals and that of iron and steel.

Mr. **Felix Dreyfus,** vice-president of Herman & Herman, Inc., manufacturers and dealers in coal tar products and intermediates, sailed for Genoa on Jan. 23, to visit the company's branches in Europe.

Mr. **Andrew M. Fairlie** has accepted an appointment as chemical engineer with the reorganized Tennessee Copper and Chemical Corporation, whose works are at Copperhill, Tenn.

Mr. **Wm. H. Gaines** is operating an electrolytic zinc plant for the Basin Salvage Co., Basin, Mont. The work is at present in the experimental stage, and several new ideas are being tried out.

Mr. **Carl M. Hansen,** widely known through his activities in connection with accident prevention, compensation and casualty insurance, as chairman of the Committee for Accident Prevention and Workmen's Compensation of the National Association of Manufacturers. Mr. Hansen, who is the author of "Universal Safety Standards," a work of thirteen volumes, has been a frequent contributor to technical journals on subjects relating to compensation, prevention and occupational diseases, as well as related subjects. He is a member of the American Society for Mechanical Engineers, American Statistical Society, Casualty, Actuarial and Statistical Society of America, and several other scientific bodies. He was born in Denmark and received his early training in that country and Germany. Coming to America in 1903, at the age of twenty-three, he entered the construction department of the Dominion Iron & Steel Company, Sydney, Cape Breton, going from there to Newfoundland as mechanical engineer for a Newfoundland mine operating syndicate; thereafter he was associated with the Atlas Engine Works at Indianapolis, Ind. On account of his interest in methods of handling work accidents in this country and in Europe, he devoted special study to this subject and became successively connected with several casualty insurance companies.

Professor **D. D. Jackson** has been designated acting head of the Department of Chemical Engineering, Columbia University, to serve in place of Professor M. C. Whitaker, absent on leave.

Mr. **K. L. Kithil,** formerly connected with the Bureau of Mines, is now general manager of the Schlesinger Radium Co., of Denver, Col.

Mr. **P. M. McHugh,** general sales manager of the Dorr Company, has left Denver for a three weeks' vacation. After spending three or four days in St. Louis on business, Mr. McHugh will spend the rest of his furlough in the South.

Mr. **W. H. McKenna,** vice-president of the Vanadium Alloys Steel Company, Pittsburgh, Pa., accompanied by Mrs. McKenna, has started on an extensive pleasure tour of Japan and China.

Mr. **S. M. Marshall** has severed his connection with the Southwark Foundry & Machine Company, of Philadelphia, to accept a position with C. P. Perin & Co., consulting engineers, 3 Rector Street, New York.

Professor F. J. Metzger of the Department of Chemical Engineering, Columbia University, has resigned his position to accept the position of manager of chemical development with the Air Reduction Company, 120 Broadway, New York. Professor Metzger will assume his new duties Feb. 1.

Mr. O. C. Ralston of the Utah section of the Bureau of Mines recently passed through Denver on his return to Salt Lake City.

Mr. C. J. Ramsburg, vice-president of H. Koppers Company, at a joint meeting of the Franklin Institute and the Philadelphia Section of the American Society of Mechanical Engineers, Feb. 6, will read a paper entitled "By-Product Coke and Coking Operations." The paper will be illustrated by lantern slides and a moving picture film showing the operation of a by-product coke plant.

Mr. Dudby Shaw is now engineer with the Air Reduction Company, 120 Broadway, New York. Mr. Shaw was formerly engineer for the Davis Bournonville Co., but left them to design and install a complete hydrogenating and compound plant. This plant was duly constructed in Austin, Tex., under the name of the Walker Refining Co., and though small was very complete, using Diesel engines for prime movers, and with direct connected generators furnishing current for the electrolytic oxygen and hydrogen cells.

Mr. R. K. Stockwell, who has been chief engineer and superintendent of construction for the Braden Copper Company at Raucaque, Chile, for the past five years, will open a Western engineering and sales office of the Robins Conveying Belt Company in Salt Lake City, Utah.

Dr. John E. Teeple, consulting chemical engineer, New York City, has been appointed associate in chemical engineering, Columbia University, and will at once assume charge of the courses in chemical works management, advanced industrial chemistry and chemical engineering.

Obituary

William Ainsworth, prominent manufacturer of precision instruments, died at his home in Denver on January 1, after a sudden attack of pneumonia, at the age of 67. Mr. Ainsworth has been a resident of Denver since 1877 and was well known in the chemical and metallurgical circles all over the country. The analytical and assaying balances of his design rank among the best used in the arts.

Mr. Archibald Colville, chairman of the directors of David Colville & Sons, Ltd., large English iron and steel manufacturers, died at The Moorings, Motherwell, on Dec. 11, 1916.

Book Reviews

Diseases of Occupation and Vocational Hygiene. Edited by **George L. Cober,** LL.D. and M.D., and **Wm. C. Hansen,** M.D. 918 pages. Price $8.00. Publishers, P. Blakiston's Son & Company.

The intelligent study and prevention of occupation diseases has received a great help and support in this voluminous work. The authors have covered the field completely and have, besides, included a copious number of references. It is a volume which should be placed in every works manager's library, be it a chemical industry or any other industry. The book is one that is well needed to-day in the modern tendency of protecting employees against conditions by which their health and future happiness are impaired.

The Engineeer in War. By **P. B. Bond.** 187 pages. McGraw-Hill Book Company, Inc.

With the strong interest taken to-day by laymen in all walks of life in military matters, this book should offer an interesting, as well as valuable source of knowledge. It is as non-technical as an extremely technical subject can be, and with its extensive glossary of military terms and its interesting and excellent illustrations, will furnish every engineer and non-engineer interested in military engineering, an excellent fount of information.

The Physico-Chemical Properties of Steel. By **C. A. Edwards,** D.Sc. Octavo (15 x 22 cm.), 229 pages, 181 illustrations. Price $3.50. London: Charles Griffin & Co., Ltd.; Philadelphia: J. B. Lippincott Company.

The author is professor of metallurgy in Sheffield University. The book is a mixture of good and indifferent. The preface speaks of very complete references being given, but the book in detail does not bear this out; e.g. Burgess' work on the critical points of iron, done at the U. S. Bureau of Standards, is not mentioned. There are three lines about the electrical resistance of iron, and no data given. But solidification of ingots, deformation and strain in working, slip-bands, and chemical and physical constitution are handled in a masterly way. It is a book for the specialist, but not entirely uniform in treatment or up to date—for which latter item present disturbed conditions in scientific literature may be some excuse.

Elementos de Electrochimica. By **V. de Vivaldi-Coaracy.** 12 x 19 cm., 218 pages. Official publication of the Electrotechnical Engineering School of Porto Alegre, Brazil.

Professor Coaracy is known in South America for his brochure on Technical Instruction in the United States. In this small book he discusses very clearly the fundamental principles of electrolysis, the theory of electric batteries and accumulators. For Brazilian students reading only Portuguese this will be a welcome book, opening to them the gateway to further studies in electrochemistry.

CURRENT MARKET REPORTS

The Iron and Steel Market

What has occurred marketwise in the past fortnight has been a development in thought rather than in action. Buyers are not conducting themselves differently than formerly. They are very reserved, in the case of both pig iron and finished steel products, about making any commitments beyond the middle of the year, while they show at least as much insistence as formerly with respect to earlier deliveries, continuing to exert pressure upon the producers to make deliveries, in case they have already bought, or seeking fresh tonnages when they have not.

On the whole it is a quiet market in pig iron and steel, as it has been since the middle or fore part of December. Such quietness is always to be expected at the holiday period, but is hardly to be expected during the second half of January. The development in thought during the past two or three weeks has been along the line that the steel mills are not likely to be under pressure indefinitely, but rather that the amount of business already booked comes close to being a measure of trade prospects in general.

The possibility of an early termination of the European war, entertained for several weeks after the German suggestion of Dec. 12, having disappeared, the trade has been able to proceed upon the assumption that

the war is to end either late this year or at some later time and in the minds of many this reduction in the uncertainty has tended to clear the prospect immensely, on account of the coincidence that granted an indefinite continuance of the war these observers expect the pressure upon the steel industry to decrease toward the end of this year. The argument in favor of this view is that on account of the ocean shipping situation iron and steel exports must decrease while eventually domestic consumption will be restricted by the high prices, and meanwhile the productive capacity is being increased. This view is held by many buyers if not the great majority. Its correctness is not admitted by all sellers or even a majority. It is admitted that exports are likely to decrease but the suggestion is made that the decrease will be brought about by increased pressure at home for steel. Undoubtedly that is the correct analysis for the next few months, for steel is growing still scarcer, but there is no great warrant for a belief that domestic requirements for steel will be greater in the second half of this year than in the first half.

EXPORTS

Iron and steel exports increased almost continuously until September, 1916, when the total exports reported by weight amounted to 643,767 gross tons, comparing with 307,656 tons as the best record before the war, made in May, 1912. In October there was a decrease of 5 per cent and in November a further decrease of 9 per cent. Since November the losses in merchant vessels through submarine and other war activity have been at a greater rate than formerly and there is no prospect of anything but continued further decreases in the amount of merchant shipping available. The intense activity at all shipyards does not suffice to make up for the losses. The export statistics as commonly quoted are not illuminating for the reason that they are statistics of declared values, not of quantities.

DOMESTIC DEMAND

The record of domestic consumption of steel during this movement has been full of surprises. It used to be considered that there was a "safe" level for steel prices, beyond which they could not advance without consumption being curtailed on account of the cost. Approximately speaking this level was reached at the end of 1915, and at that time the mills were sold up to about the middle of July, 1916. They have continued under great pressure for six and a half months longer, showing that the consumption was not noticeably retarded by the passing of the traditional. It does not follow, however, that there is no price level at which consumption would be curtailed sufficiently to make an impress upon the mill position. There is no means of ascertaining the average price of the steel now being shipped but there is one concrete fact that is suggestive. On July 1, 1916, the mills had on their books a tonnage of business, which if suitably distributed among the different finished products would have carried them to this present date, and prices at that time were on an average $14 per net ton below present prices. Some of the business now being filled was booked prior to July 1 and some of it was booked later. It is still to be determined whether full consumption would continue were all consumers forced to pay present prices, and the common view among consumers is that it would not. It is to be observed that the amount of strictly "war steel" being shipped is not a large proportion of the total output. It is believed that after the war there will be certain fresh demands for steel, at the more moderate prices that will then prevail, and such a view cannot well be harmonized with an idea that present domestic consumption is to continue indefinitely, during the war, at the present high rate, for if so the demand after the war would be still greater and steel prices ought to advance instead of decline. Such a suggestion may appear rather far fetched but it is worth while to look at the matter from this angle. If there is good reason, and there certainly is, to expect a good demand for steel after the war, it is absurd not to consider the restrictive influence that war prices must exert on some lines of consumption..

TRANSPORTATION

The industry is suffering still more severely from lack of full transportation facilities. Coke shipments from the Connellsville region are about 25 per cent less than the requirements of the blast furnaces tributary to the region. At some groups of furnaces one or more stacks are banked and the remainder pushed to capacity, while other producers slow down their operations. At many furnaces, indeed, there has not been enough coke with which to bank. The curtailment in pig iron production does not appear to have directly caused any decrease in steel output, nor has it affected the pig iron market, except to bring out some insistent inquiry for small lots of malleable and foundry iron for immediate shipment to consumers dependent upon western Pennsylvania, valley and lake front furnaces.

Shipments of steel, particularly in the Pittsburgh and valley districts, have been curtailed by a few per cent on account of the railroads being unable to move loaded cars freely. Car shortages are not so much in evidence. The strenuous efforts made by the railroads to move empty cars appear to have been more or less successful but trouble crops out in this new manner. Some mills which a month ago could not secure enough empties for loading are now confronted with the danger that if they load cars they will be charged demurrage because they are not taken away.

Prices have been practically stationary all along the line. Effective January 23 the Steel Corporation subsidiaries advanced their prices on shapes and plates by $3 a ton, to 3.25c. for shapes and 3.75c. for plates, but all such quotations are practically nominal, being for "shipment at mill convenience." Buyers feel that they need not concern themselves with deliveries so far in the future that it would be convenient for mills to make them.

Non-Ferrous Metal Market

Thursday, Jan. 25—Copper is higher on account of a scarcity of supplies, and tin has advanced in an unsettled market. Lead is virtually unchanged but supplies are scarce, spelter is slightly higher but the market has been quiet. Antimony has been in good demand and is higher.

Copper.—The large producers have not been offering any copper for sale before the middle of the year and the market has been dull. The refinery of the American Smelting & Refining Company at Perth Amboy, N. J., has been closed for almost two weeks on account of a strike, which is understood to have been settled now. This strike and the freight congestion in various parts of the country have tended to shorten supplies somewhat. Electrolytic is quoted at 32.50 to 33.00 cents with Lake at 31.50.

Tin.—Cables from London have been held up and naturally the market here has been in more or less of a confused state. There has been a fairly good demand for prompt deliveries but sellers have been shy. Straits tin is now quoted at 45.50 cents, an advance of about 3 cents in the last two weeks. There is a scarcity of

Banca tin reported. Arrivals to date this month are 2650 tons.

Lead.—This market has been very dull, but supplies are scarce and the independents are asking up to 8.00 cents with the trust price unchanged at 7.50.

Spelter.—Spelter is about ½ cent higher, but the market has been quiet. The difficulty of obtaining freight room is holding back export business. Producers have not shown any desire to push domestic sales and are banking on a larger export business to take care of the enormous production. The quotation for prompt shipment is 10.00 cents at New York.

Other Metals.—Antimony is in good demand and has jumped up 2 cents to 16.50. Aluminium is quoted at 56.00 to 60.00 cents, magnesium $3.00 to $3.50, electrolytic nickel at 50.00 cents, cadmium at $1.50, quicksilver $80.00, platinum $90.00, cobalt $1.50 and silver at 76½ cents.

Chemical Market

Coal tar products attracted possibly more attention than any other branch of the industry during the past fortnight. There appear to be an important number of consumers who are anxious to cover and have been taking advantage of any possible loopholes in the market and closing whenever there was a possibility of a good buy.

Benzol has been subject to quite a persistent inquiry. A number of large consumers are in want of supplies and must have them for nearby deliveries. The general position has been a firm one for any delivery up to March. Beyond March, the position is rather uncertain, as new productions will reach the market at that time, making the general situation a peculiar one. During the two weeks spot business ranged from 56c. to 58c. with contracts over the year averaging 51c. to 52c. One large contract was placed by one of the coke companies on the basis of 44c. for deliveries over the year but it is generally admitted that only a favored buyer could work a price such as this. The stipulation was that the benzol was not to enter into the munition trade, as the selling company is German owned, and will not sell for other than dye manufacture.

The *toluol* situation has been firmer than the benzol one. For spot and nearby delivery it has not been possible to do better than $1.75 to $1.80 and on contract $1.45 to $1.50 is named. A large munition concern that lately purchased on a very low basis has endeavored to cover again at a price about approximately equal to that upon which their last purchases were made. At the moment of writing they have not been able to secure offers within 25c. of their bid.

Aniline oil has been another coal tar product that has firmed up considerably, principally due to the heavy export inquiry from England. The market has at times reached below the 20c. level but to-day there is but little likelihood of securing important amounts under 25c. Even with the higher market, selling prices allow of a very narrow margin of profit to makers considering the present price of benzol and acids.

In contrast the market for *phenol* has been weak and the leading makers have all lowered their asking rate with but little actual consuming inquiry noted.

In the intermediates, *H acid* (the amidonaphthol disulphonic acid 1:8:3:6) continues to attract much attention. There are about five producers, two of which make for their own consumption. The product is an extremely difficult one to make and complicated machinery is used. It is the intermediate for the production of *direct black*. Contracts are nominally quoted at $2 per pound for long terms basis 80 per cent.

Of the pharmaceutical chemical salts, *beta naphthol benzoate* attracts much attention owing to the important export inquiry. There are about five producers on a commercial scale. Spot prices range from $17 to $20.

Alpha-naphthylamine is attracting considerable attention and as the output is a restricted one well under control a number of interests in the trade are contemplating its manufacture.

A production of *benzoyl chloride* is announced. This is an important intermediate for the manufacture of *malachite green*. It is quoted at $18 on spot and about $16 on contract. *Benzyl* and *benzal chlorides* are being made by several producers, the first named selling at $3 and the latter at $5.00. *Carbonyl chloride* and, of course, *Michler's ketone* is now produced in this country in a small way.

As the Bayer patents covering *aspirin* will expire next month, an active preparation is being made openly to manufacture the product. Of course, there has been a production of *acetyl salicylic* for some time and sold in a quiet way, but there will probably be a dozen makers ready for business as soon as the Bayer patents run out. Supplies of *acetic anhydride* are scarce, however, and these new makers will be up against a raw material problem.

In heavy chemicals, the interval has been a rather quiet one. On the spot *soda ash* is perhaps five points lower than two weeks ago. Some business has passed but of course with such an enormous production as is noted at the moment business must pass. *Caustic soda* is easier, resale lots, perhap, keeping the market down to a level to which there was no legitimate title. Makers are well sold up and the export movement is really tremendous. For contracts, makers hold out at about the same prices prevailing a fortnight ago.

Bichromate of soda has taken a sharp drop, despite the efforts of leading interests to maintain the market. This market has been practically in the hands of one firm for many years past but owing to new inducements held out by high prices and an increased production of chrome ore at home there are now seven producers. Three of these manufacture for their own use. *Bichromate of potash* remains quite steady.

Cyanides of domestic manufacture continue high with practically no supplies available, particularly the potassium base. Japanese offers continue persistent and doubt is expressed whether present values will hold indefinitely in face of these offers.

Chlorates are about unchanged and the new manufacturers of this product are seemingly marketing their output without forcing values downward. *Copper sulphate* has been in fair request and values have not undergone substantial change.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET JANUARY 25, 1917

Acetone, Drums	lb.	.22½ —	.23
Acid, acetic, 28 per cent	100 lb.	3.25 —	3.50
Acetic, 56 per cent	100 lb.	7.00 —	7.10
Acetic, glacial, 99¼ per cent carboys	lb.	.22 —	.22½
Boric, crystals	lb.	.11½ —	.12
Citric, crystals	lb.	.65 —	.66
Hydrochloric, commercial, 18 deg.	lb.	.01¼ —	.01⅜
Hydrochloric, 20 deg.	lb.	.01⅜ —	.01½
Hydrochloric, C. P., conc., 22 deg.	lb.	.01½ —	.01⅝
Hydrofluoric, 30 per cent, in barrels	lb.	.04¾ —	.05
Lactic, 44 per cent	lb.	.12 —	.13
Lactic, 22 per cent	lb.	.05½ —	.06¼
Nitric, 36 deg.	lb.	.04½ —	.04⅝
Nitric, 42 deg.	lb.	.05½ —	.05⅝
Oxalic, crystals	lb.	.43 —	.45
Phosphoric, 85 per cent	lb.	.30 —	.32
Picric	lb.	.65 —	.75
Pyrogallic, resublimed	lb.	3.15 —	3.20
Sulphuric, 60 deg., Brimstone	ton	20.00 —	21.00
Sulphuric, 66 deg.	ton	25.00 —	26.00
Sulphuric, oleum (Fuming), tank cars	ton	35.00 —	36.00
Tannic, U. S. P. bulk	lb.	.90 —	1.00
Tartaric, crystals	lb.	.65 —	.66
Alcohol, grain, 188 proof	gal.	2.72 —	2.74
Alcohol, Wood, 95 per cent	gal.	1.00 —	1.02
Alcohol, Denatured, 180 proof	gal.	.65 —	.67
Alum, ammonia lump	lb.	.04 —	.04½
Alum, chrome	lb.	.22 —	.23
Alum, potash lump	lb.	.05¼ —	.05½
Aluminum Sulphate, technical	lb.	.01⅞ —	.02

Aluminum Sulphate, iron free	lb.	.03½	—	.03¾
Ammonia aqua, 26 deg. carboys	lb.	.05	—	.05½
Ammonia anhydrous	lb.	.24	—	.26
Ammonium carbonate	lb.	.12½	—	.13½
Ammonium nitrate	lb.	.14	—	.14¼
Ammonium sulphate, domestic	lb.	.04½	—	.04⅝
Amyl acetate	gal.	4.00	—	4.25
Arsenic, white	lb.	.09½	—	.09¾
Arsenic, red	lb.	.65	—	.70
Barium chloride	ton	90.00	—	95.00
Barium sulphate (Blanc Fixe) powder	lb.	.04	—	.04½
Barium nitrate	lb.	.12	—	.12½
Barium peroxide, basis 70 per cent	lb.	.27	—	...
Bleaching powder, 35 per cent	lb.	.04	—	.04¼
Borax, crystals, sacks	lb.	.08	—	.08¼
Brimstone, crude	ton	28.00	—	28.50
Bromine, technical	lb.	1.40	—	1.45
Calcium, acetate, crude	lb.	.03½	—	.03¾
Calcium, carbide	ton	85.00	—	87.00
Calcium chloride, 70-75 per cent, fused, lump,	ton	22.50	—	23.00
Calcium sulphate	lb.	.01	—	.01½
Calcium phosphate precipitate	lb.	.30	—	...
Carbon bisulphide	lb.	.04½	—	.04¾
Carbon tetrachloride, drums	lb.	.15	—	.16
Caustic potash, 82-92 per cent	lb.	.84	—	.86
Caustic soda, 76 per cent	100 lb.	4.00	—	4.05
Chlorine, liquid	lb.	.15	—	.16
Copperas	100 lb.	1.10	—	1.20
Copper carbonate	lb.	.35	—	.37
Copper cyanide	lb.	.70	—	...
Copper sulphate, 99 per cent, large crystals	lb.	.11⅞	—	.12
Cream of tartar, crystals	lb.	.40	—	.41
Epsom salt, bags	100 lb.	1.80	—	1.90
Formaldehyde, 40 per cent	lb.	.12	—	.12½
Glauber's salt	100 lb.	.65	—	.75
Glycerine, C. P.	lb.	.53	—	.53½
Iodine, resublimed	lb.	4.10	—	4.20
Iron oxide	lb.	.02½	—	.10
Lead acetate, white crystals	lb.	.13½	—	.13¾
Lead arsenate	lb.	.08½	—	.10
Lead nitrate	lb.	.16	—	.17
Litharge, American	lb.	.09¼	—	.09½
Lithium carbonate	lb.	1.02	—	1.03
Manganese dioxide	lb.	.65	—	.70
Magnesium carbonate, technical	lb.	.12¾	—	.13
Nickel salt, single	lb.	.14	—	...
Nickel salt, double	lb.	.11	—	...
Phosphorus, red	lb.	1.10	—	1.20
Phosphorus, yellow	lb.	.65	—	.70
Potassium bichromate	lb.	.39	—	.40
Potassium bromide, granular	lb.	1.30	—	1.35
Potassium carbonate calcined, 80-85 per cent,	lb.	.30	—	.35
Potassium chlorate, crystals	lb.	.63	—	.64
Potassium cyanide, 98-99 per cent	lb.	2.30	—	2.40
Potassium iodide	lb.	3.35	—	3.45
Potassium muriate, 80-85 per cent basis of 80 per cent,	ton	360.00	—	375.00
Potassium nitrate	lb.	.31	—	.32
Potassium permanganate	lb.	3.50	—	4.00
Potassium prussiate, red	lb.	2.50	—	2.75
Potassium prussiate, yellow	lb.	.88	—	.90
Potassium sulphate, 90-95 p.c. basis 90 p.c.	ton	260.00	—	275.00
Rochelle salts	lb.	.34	—	.34½
Sal ammoniac, gray gran	lb.	.09½	—	.10
Sal ammoniac, white gran	lb.	.16¾	—	.17¼
Sal soda	100 lb.	1.05	—	1.15
Salt cake	100 lb.	.70	—	.75
Silver cyanide, based on silver market	oz.	.72	—	...
Silver nitrate	oz.	.47½	—	.49½
Soda ash, 58 per cent, light, flat	lb.	2.80	—	2.90
Soda ash, 58 per cent, dense, flat	lb.	3.25	—	3.30
Sodium acetate	lb.	.08½	—	.09
Sodium benzoate	lb.	8.00	—	8.25
Sodium bicarbonate, domestic	100 lb.	1.65	—	1.70
Sodium bicarbonate, English	lb.	.02¾	—	.03
Sodium bichromate	lb.	.16	—	.16½
Sodium bisulphite, powd.	lb.	.04½	—	.04¾
Sodium chlorate	lb.	.25	—	.26
Sodium cyanide	lb.	1.60	—	1.65
Sodium fluoride, commercial	lb.	.12	—	.14
Sodium hyposulphite	lb.	.01½	—	.01¾
Sodium nitrate, refined	lb.	3.27½	—	3.30
Sodium nitrite	lb.	.11¾	—	.12½
Sodium peroxide	lb.	.90	—	.95
Sodium phosphate	lb.	.04¼	—	.04⅝
Sodium prussiate, yellow	lb.	.32	—	.33
Sodium silicate, liquid, 60 deg.	100 lb.	1.65	—	1.75
Sodium sulphide, 30 per cent crystals	lb.	.02	—	.02¼
Strontium nitrate	lb.	.26	—	.28
Sulphur chloride, drums	lb.	.09½	—	...
Sulphur, flowers, sublimed	100 lb.	2.30	—	2.35
Sulphur, roll	100 lb.	1.95	—	2.00
Sulphur, crude	ton	35.00	—	38.00
Tin bichloride, 50 deg.	lb.	.13½	—	.13¾
Tin oxide	lb.	.46	—	.48
Zinc carbonate	lb.	.24	—	.26
Zinc chloride	lb.	.12¾	—	.14½
Zinc cyanide	lb.	.50	—	...
Zinc dust	lb.	.20	—	.22
Zinc oxide, American process XX	lb.	.11	—	.11¼
Zinc sulphate	lb.	.06½	—	.06¾

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.56½	—	.59
Benzol, 90 per cent	gal.	.55	—	.60
Toluol, pure, water white	gal.	1.75	—	1.80
Xylol, pure, water white	gal.	1.00	—	1.15
Solvent naphtha, water white	gal.	.21	—	.22
Solvent naphtha, crude heavy	gal.	.13	—	.18
Creosote oil, 25 per cent	gal.	.25	—	.27
Dip oil, 20 per cent	gal.	.24	—	.25
Pitch, various grades	ton	8.00	—	18.00
Carbolic acid, crude, 95-97 per cent	lb.	.85	—	.90
Carbolic acid, crude, 50 per cent	lb.	.60	—	.65
Carbolic acid, crude, 25 per cent	lb.	.24	—	.26
Cresol U. S. P.	lb.	.18	—	.22

Intermediates, Etc.

Alpha naphthylamine	lb.	1.25	—	1.30
Aniline oil	lb.	.23	—	.24
Aniline salts	lb.	.27	—	.30
Anthracene, 80 per cent	lb.	.10	—	.10½
Benzaldehyde	lb.	4.50	—	5.25
Benzidine, base	lb.	1.65	—	1.75
Benzoic acid	lb.	8.50	—	8.50
Beta Naphthol	lb.	.80	—	.90
Dimethylaniline	lb.	.60	—	.65
Diphenylamine	lb.	.85	—	.90
H-acid	lb.	2.25	—	2.50
Metaphenylenediamine	lb.	1.75	—	1.85
Monochlorbenzol	lb.	.32	—	.34
Naphthalene, flake	lb.	.09	—	.09¼
Naphthionic acid, crude	lb.	1.85	—	2.00
Ortho-amidophenol	lb.	...	—	...
Ortho-toluidine	lb.	1.20	—	1.30
Para-amidophenol base	lb.	4.25	—	4.50
Para-amidopherol hydrochloride	lb.	6.00	—	6.25
Paranitraniline	lb.	1.40	—	...
Paraphenylenediamine	lb.	3.50	—	4.00
Para toluidine	lb.	1.60	—	1.70
Phenol U. S. P.	lb.	.48	—	.50
Resorcin technical	lb.	9.00	—	9.25
Resorcin, pure	lb.	17.00	—	17.50
Salicylic acid	lb.	.90	—	1.00
Salol	lb.	1.90	—	2.00
Sulphanilic acid	lb.	.35	—	.36
Toluidine-mixture	lb.	.90	—	1.10

Petroleum Oils

CRUDE (AT THE WELLS)

Pennsylvania	bbl.	3.05	—	...
Corning, Ohio	bbl.	2.38	—	...
Somerset, Ky., 32 deg. and above	bbl.	2.18	—	...
Wooster, Ohio	bbl.	2.00	—	...
Indiana	bbl.	1.63	—	...
Illinois	bbl.	1.82	—	...
Oklahoma and Kansas	bbl.	1.70	—	...
Caddo, La., light	bby.	1.70	—	...
Corsicanna, Tex., light	bbl.	1.70	—	...
California, 14 to 17.9 deg.	bbl.	.73	—	...
25 to 25.9 deg.	bbl.	.82	—	...

LUBRICANTS

Black, reduced, 29 gravity, 25-30 cold test	gal.	.13½	—	.14
Cylinder, light		.21	—	.26
Cylinder dark		.18	—	.19
Extra cold test		.26	—	.31
Paraffine high viscosity		.29½	—	.30
Paraffine, .903 spec. gr.		.21½	—	.22
Paraffine, .865 spec. gr.		.18½	—	.19

Flotation Oils

Pine oil, steam distilled	gal.	.59	—	...
Pine oil, destructively distilled	gal.	.47	—	...
Pine-tar oil	gal.	.19	—	...
Pine-tar oil, double refined	gal.	.30	—	...
Pine oil, light	gal.	.37	—	...
Pine oil, heavy	gal.	.26	—	...
Pine tar, thin	gal.	.18	—	...
Turpentine, crude	gal.	.38	—	...
Hardwood oil, f.o.b. Michigan	gal.	.16	—	...
Creosote, coal tar neutral	gal.	.15	—	...
Creosote, coal tar, acid	gal.	.21	—	...
Coal tar, thin	gal.	.12	—	...

Vegetable and Other Oils

China wood oil	gal.	.13	—	.13¼
Cottonseed oil, crude	gal.	.83	—	...
Linseed oil, raw	gal.	.95	—	...
Peanut oil, crude	gal.	.85	—	.86
Rosin, 280 lb.	bbl.	6.30	—	...
Rosin oil, first run	gal.	.38	—	...
Rosin oil, fourth run	gal.	.70	—	...
Soya bean oil, Manchuria	gal.	.12	—	.12¼
Turpentine, spirits	gal.	.55½	—	...

Miscellaneous Materials

Barytes, floated, white, foreign	ton	38.00	—	40.00
Barytes, floated, white, domestic	ton	25.00	—	35.00
Beeswax, white, pure	lb.	.48	—	.50
Carnauba wax, highest grade	lb.	.50	—	.51
Chalk, light, precipitated, English	lb.	.03¼	—	.05½
Feldspar	ton	8.00	—	12.00
Fuller's earth, powdered	100 lb.	.80	—	1.05
Plaster of Paris	bbl.	1.50	—	1.70
Red lead, dry, carloads	lb.	.09¾	—	...
Soapstone	ton	10.00	—	12.50
Talc, American, white	ton	10.00	—	13.00
White lead, dry	lb.	.08¾	—	...

Refractories, Etc.

(F.O.B. WORKS)

Chrome brick	net ton	120.00	—	130.00
Chrome cement, Grecian	net ton	80.00	—	90.00
Clay brick, first quality fireclay	per 1000	40.00	—	50.00
Magnesite, Grecian, dead burned	net ton	85.00	—	90.00
Magnesia brick, Grecian, 9 x 4½ x 2½	net ton	135.00	—	140.00
Silica brick	per 1000	40.00	—	45.00

Ferroalloys

Ferro-carbon-titanium, carloads	lb.	.08	—	...
Ferrochromium	lb.	Nominal		
Ferromanganese, domestic, delivered	ton	175.00	—	180.00
Ferromanganese, English, seaboard	ton	165.00	—	...
Ferromolybdenum	lb.	4.00	—	...
Ferrosilicon, 50 p.c., carloads, del. Pittsburgh	ton	125.00	—	150.00
Ferrosilicon, 50 p.c., contract, del. Pittsburgh	ton	100.00	—	...
Ferrotungsten, 75-85 p.c., f.o.b Pittsburgh	lb.	1.95	—	...
Ferrovanadium, f.o.b. works	lb.	2.75	—	3.00

INDUSTRIAL

Financial, Construction and Manufacturers' News

Financial

A syndicate composed of the principal banking and business interests of Norway has purchased the seven-eighths interest in the Arctic Coal Company, held by J. M. Longyear and Frederick Ayer, of Boston.

The deal included some minor properties, including ships, but the major properties are the famous Spitzbergen mines, located on the Spitzbergen Islands in the Arctic that lie north of Norway and only about 700 miles from the North Pole. A new company has been formed with a capital of 10,000,000 crowns ($2,680,000).

The Arctic company's property covered about 170 square miles. Most of the work completed has been of a development nature and the output has not amounted to much more than 200,000 tons. Exploration showed many valuable and extensive veins of semi-bituminous coal, one alone disclosing 100,000,000 tons.

All Points Trading Company, Inc., New York. Capital $5,000. Incorporated to manufacture drugs, medicines, paints, chemicals, oils, dyestuffs, by G. V. Sheridan, S. D. Muney and A. L. Berman, 55 West 110th Street.

The Alto Cotton Oil & Mfg. Company, Alto, Texas. Capital $25,000. Incorporators: H. H. Berryman, J. E. Waters and T. Arrant.

The American Abrasives Company, has been incorporated at Dover, Del., by E. G. Neiss Wayne, L. L. Voigt, George M. Harton, all of Pittsburgh.

The American Magnesium Corporation, Niagara Falls, N. Y., has been incorporated with a capital of $300,000, in New York State. The charter states that the company is authorized to manufacture magnesium, barium, calcium and other metals. The directors are E. W. Burdick, I. J. Hallenbeck and J. J. Devereux, all of New York.

Aroostook Pulp & Paper Company, Boston, Mass. Capital $500,000. Incorporators: A. N. Blandin, George S. Lewis, 147 Milk Street, and S. F. Johnson.

Bald Hill Mining Company, Seattle, Wash. Capital $1,000,000. Incorporators: A. C. Smith, G. Methven, L. Stadler, E. W. Winslow and B. T. Ulrich.

The Blackstone Oil and Paint Company, Cleveland, Ohio. Capital $10,000. Incorporators: G. T. Baudors, W. S. Searles, J. R. Robinson, A. F. Gaughn and T. A. Gillespie

Bristol Power, Pulp & Paper Company, Wilmington, Del. Capital $1,000,000. Incorporated to manufacture wood pulp and paper, by K. M. Dougherty, M. C. Donohue and F. Giles, Wilmington, Del.

Burdett Oxygen Company, Chattanooga, Tenn. Capital $100,000.

Columbia Bronx Corporation, Freeport, N. Y. Capital $450,000. Incorporated as founders, welders, etc., by L. H. H. Rose, H. W. Bennett and J. A. Sutter, East Ocean Parkway, Brooklyn.

Congress Copper Company, Kittery, Me. Capital $2,500,000. Incorporated to operate mines and mineral lands.

Connecticut Smelting & Foundry Corporation, Wilmington, Del. Capital $500,000. Incorporation to conduct mills for the treating of metals.

Cornell Pulp Reduction Company, Inc., Watertown, N. Y. Capital $50,000. Incorporated to deal in pulp, hardwood, fibrous products. Incorporators: W. N. Cornell, G. H. Burna and P. B. Hudson, Watertown.

Coeur D'Alene Federal Mines Corporation, Portland. Capital $1,000,000. Incorporated to do mining business by B. B. Sanderson, E. V. Mann, Charles D. Booth.

D. and L. Mfg. Company, New York. Capital $10,000. To manufacture metal specialties. Incorporated by J. Miller, M. Dobrikin and M. Lansky, 2322 Crotona Avenue, Bronx.

H. T. Dakin Paper Company, Waterbury, Conn. Capital $25,000. Incorporated to manufacture and deal in all kinds of paper, by R. Dumouchal, A. H. Anderson and R. S. Walker.

Delta Beet Sugar Corporation, New York. Capital $200,000. Incorporated to manufacture sugar beets, sugar, by-products, by T. D. Adams, M. G. Laux and A. H. Curtsi, 43 Exchange Place.

Diversey Foundry Company, Chicago, Ill. Capital $10,000. Incorporators: Catherine M. Rowbottom, James J. Rowbottom.

Easterbrook Copper Company, Delaware. Capital $100,000. Incorporated to do a general mining business by O. Powell, E. W. Stevens, Gwendolyn J. McNiel, all of New York.

The Electric Smelting Corporation, Baltimore, Md. Capital $100,000. Incorporators are Attorney Adolph Schoeneis, J. F. Dirzuweit and Katharine Dirzuweit, of Baltimore.

J. P. Eustis Mfg. Company, Cambridge, Mass. Capital $103,000. Incorporated to deal in metals by J. P. Eustis, Newton, Mass. Treasurer, Frank Owen White, Brookline, Mass., clerk.

Fall Mountain Pad & Paper Company, Vermont. Capital $10,000. Incorporators: F. L. Thompson, F. A. Moore, H. B. Underhill, Bellows Falls and J. W. King, Walpole, N. H.

Farbenfabriken of Elberfeld Company, Paterson, N. J. Capital $125,000. Incorporation to manufacture chemicals, dyes, etc.

Flax Fiber Company, Helena, Mont. Capital $50,000. Incorporated to engage in the manufacture of fiber. Incorporator: George Person and others.

Fritzsche & Kleason, Buffalo, N. Y. Capital $10,000. Incorporated to a paint, dye and varnish business by C. A. Fritzsche, H. L. Jauch and R. J. Kimball.

Globe Chemical Company, Broadway, Jersey City. Capital $3,000. Incorporated to manufacture chemicals. Incorporators: H. W. F. Lorenz, A. Proven, J. F. W. Lorenz and L. J. Brown, Jersey City.

Good Faith Oil & Gas Co, Dover, Del. Capital $240,000. Incorporators: Julia S. Jones, A. B. Magee, H. N. Pembelton, all of Dover.

Hattiesburg Pulp & Board Company, Portland. Capital $1,250,000. Incorporated to manufacture wood and paper.

The Henle Wax Paper Mfg. Company, Inc. Capital $50,000. Incorporated to manufacture paper, paper pulp, cloth and textile fabrics. Incorporators: R. Vallantine, P. A. Schmitt and C. O. Maas, 57 West 75th Street.

Hudson Bay Paint Company, Inc., Buffalo, N. Y. Capital $25,000. Incorporated to manufacture paint and varnish, by G. I. Shaumacher, 1616 Delaware Avenue; A. A. Hoestermann, 69 Moulier Street, and W. J. Lavery, 19 Pauline Street, Buffalo.

Ideal Acetylene Company, Inc., Delaware. Capital $400,000. Incorporated to manufacture and sell acetylene and gas generators, by H. E. Latter, N. P. Coffin, Wilmington, Del., and C. M. Egner, Elkton, Md.

Ideal Leather Company., Inc., New York. Capital $10,000. Incorporated to manufacture leather and chemicals, by James V. Padula, G. Compolataro, Newark, and Jos. Vicarist, Belleville.

Interocean Chemical Corporation, New York. Capital $750,000. Incorporated to manufacture coal tar products, explosives, etc., by H. S. Perrigo, 660 St. Nicholas Avenue, New York City, H. Havens, 55 Hanson Place, New York City, and S. C. T. Dodd, 1918 Avenue H, Brooklyn.

Jersey Consolidated Copper & Gold Mining Company, Wilmington, Del. Incorporated to do mining business. Capital $100,000.

K. & T. Chemical Corporation, New York. Capital $36,000. Incorporation to manufacture chemicals, dyestuffs, oils, paints, etc., by W. R. Root, 1487 Sterling Place, Brooklyn; B. L. Karliner, 989 Simpson Street, New York City; F. J. Byrne, 529 Lenerts Avenue, Richmond Hill.

Keystone Leather Chemicals Company, Delaware. Capital $25,000. Incorporated to manufacture chemicals and chemical compounds.

Langan Paint Company, Kewanee, Ill. Capital $40,000. Incorporators Jas. M. Langan, C. A. Langan and Jas. F. Langan

The Lehigh Valley Facing Company, Wilmington, Del. Capital $100,000. Incorporated to manufacture foundry facings. Incorporated by K. M. Dougherty, M. C. Donohue and F. Giles, Wilmington, Del.

McAuliffe Paper Company, Inc., Burlington, Vt. Capital $50,000. Incorporators: W. H. McAuliffe, Ottawa; E. L. and H. J. McAuliffe, of Burlington.

Maratimo Coating Corporation, Wilmington, Del. Capital $50,000. Incorporated to manufacture and deal in chemicals.

Matthews Steel Co., Newark, N. J. Capital, $50,000. Incorporated to deal in iron and steel by J. Swenson, J. S. Swenson and H. Todd, Newark.

Metasap Chemical Company, 10-20 Essex Street, Harrison, N. J. Incorporated to sell chemicals. Incorporators: A. Phillips, 25 Hilisale Avenue, Newark; R. Buehringer, 112 Second Avenue, Newark; W. E. Wachman, 102 Lord Avenue, Bayonne, and C. F. Sunck, 319 Clifton Avenue, Newark.

Moore Paper Mills Corporation, Albany, New York. Capital $50,000. Incorporated to manufacture paper and box board by William P. Goodspeed, Charles G. and Blanche S. Moore, of Buffalo.

The Ohio Pattern Works & Foundry Company, Cincinnati, Ohio. Capital $200,000. Incorporators: Jos. E. Hausfeld, Amelia S. Hausfeld, Ed. B. Hausfeld, Victor E. Tresise, Grace L. Tresise and Fannie Pearl Tresise.

Outwear Leather Corporation, New York. Capital $350,000. Incorporated to manufacture rubber articles, by M. T. Kelly, W. Phinney and G. H. Wyckoff, 115 Broadway.

Parsons Bar Company, Charlotte, N. C. Capital $100,000. To deal in dyestuffs and chemicals. Incorporated by W. A. Parsons, B. B. Parsons and J. M. Barr, of Charlotte.

Patent Record Publishing Co., Inc., New York. Capital $75,000. Incorporated to publish, print, deal in metal paper, products, cloth, drugs, photographical, scientific apparatus by H. L. Varian, E. H. Ball and W. D. Kemp, 489 Fifth Avenue.

The Pequannock Valley Paper Company, Morristown, N. J. Capital $150,000. Incorporated to carry on the manufacturing business at Butler, by Isabel C. White, Fred S. White, Walter C. White and Joseph C. White.

The Phillips Lead & Supply Co., Providence, R. I. Capital stock increased from $30,000 to $100,000.

Quick-Kleen Soap Company, Inc., Brooklyn, N. Y. Capital $5,000. Incorporation to manufacture soap, perfumeries, oils, gases, chemicals. By C. H. Hoag, D. Deminger, J. A. Bailie, 505 De Kalb Avenue, Brooklyn, N. Y.

Royal Dye Works, Inc., New York. Capital $10,000. Incorporated to dye furs, skins and to make dyes and chemicals, by L. Scorsons, F. P. Kamholz and W. Koenig, 25 Echo Road, New Rochelle.

Sedalia-Lebanon-Nowata Lead and Zinc Company, Nowata, Okla. Capital $100,000. Incorporated by A. C. Hough, Nowata; L. C. Mayfield, Lebanon, Mo., and J. W. Palmer, Sedalia, Mo.

Seneca Copper Corporation, New York. Capital $1,000,000. Incorporated to do mining, milling gold, silver, copper, etc., products and by-products, deal in agricultural products, drugs, furniture, machinery, supplies, etc., by F. G. Fischer, S. J. Kramer and K. A. Duffy, 15 Broad Street, New York City.

Sinclair Gulf Corp., Albany, N. Y. Capital $5,000,000. Incorporated to carry on a mineral oil and gas business.

Tadaco Turpentine Co., Mobile, Ala. Capital $5,000. Incorporated to engage in the general timber and turpentine business in south Alabama. Incorporators, T. J. Taylor, S. Lowenstein, A. Lowenstein, H. C. Taylor, R. B Crum, J. W. Gray, D. Durant and B. C. Pickens.

Triangle Leather Goods Corp., New York. Capital $5,000. Incorporated to manufacture leather novelties. Incorporators, M. Moskowitz, F. and J. Hart, 223 East Sixth Street.

Troy-Kalispell Mining Company, Troy, Idaho. Capital $300,000. Incorporated to take over the 15 claims of Wood & Hogan, 12 miles west of Troy, in Idaho.

Umans Dye Works, Inc., New York. Capital $16,000. Incorporators, E. London, R. and H. Umans, 212 West 111th Street.

The United States Smelting & Refining Co. has purchased a controlling interest in the Big Four Exploration Company, which handles 800 tons daily of old mill dumps in Utah. The Big Four company's office is in Newhouse.

Universal Leather Company, Newark, N. J. Capital $50,000. Incorporated to manufacture and deal in leather goods. Incorporated by Walter F. Gins, Stanleigh P. Friedman, New York; Charles B. Kuttner and Meyer E. Ruback, Newark, N. J.

The Wiser Oil Company, Bartlesville, Tex. Capital increased from $100,000 to $2,000,000.

Wright Chemical Corporation, Newark, N. J. Capital $100,000. Incorporated to manufacture chemicals, dyes, dyestuffs, acids, alkalis, salts and paints. Representative Allan E. Crocker 38 Park Row, New York.

Yellow Pine Paper Mill Co., Orange, Tex., has increased its capital from $500,000 to $1,000,000.

Construction and Operation

Arizona

BISBEE.—The new smelter of the United Verde Extension Company is expected to be ready in fourteen months from the time work is actually commenced. Until this smelter is completed, the Extension Company will continue to market its ores at Douglas and Humboldt.

Arkansas

FORT SMITH.—The Fort Smith Smelter Company will build a $350,000 lead and zinc smelting plant to contain 6,000 retorts.

California

JACKSON—Messrs. Simmonds & Latham of Melones will build a $15,000 cyanide plant near Jackson to work tailings of the Argonaut mine. There are 200,000 tons of this material available. A flotation process may be installed later.

LONG BEACH.—Mr. Cyril E. Brayton, of Seattle, plans the erection of a $150,000 plant at Long Beach for the manufacture of strontium nitrate. The proposed plant will be located just west of the California Glass Insulator Works near the Southern Pacific Main Line between Long Beach and San Pedro. It will be operated as the Brayton Manufacturing & Chemical Company.

LOS ANGELES.—The R. W. Pridham Paper Mill will make repairs and alterations costing $50,000. The plant was recently damaged by fire.

SANTA BARBARA.—The news that a potash factory would be established at Summerland, near Ortega Hill, has aroused millionaire residents of exclusive Montecito. The opposition is based on the contention that the benefits to the community would be small in comparison with the objection of cutting the kelp which would leave the coast open to the full force of the storms, resulting in heavy damage.

Colorado

DELTA.—The Holly Sugar Company plans the erection of a $1,500,000 factory at Delta, Colorado and also plans to purchase another factory at Grand Junction, tremendously increasing its beet sugar output.

DENVER.—The Stearns-Roger Manufacturing Company has been awarded the contract for the construction of a $1,500,000 beet sugar factory to be erected at Delta, Utah.

Connecticut

FAIRFIELD.—The Hamilton & De Loss Company, recently organized, with $300,000 capital, has secured a site for a factory near the Handy & Harmon plant and plans the erection of a $100,000 structure. The company will manufacture metal parts and will use scrap silver, steel, brass and copper, and expects to employ from 500 to 800 hands. H. H. Hamilton, President of the Whiting Manufacturing Company, is president of the new company, and H. H. De Loss, president of the Handy & Harmon Company, is also interested.

HARTFORD.—The Russell Company is erecting a new dye house, 34 x 80 feet, two stories high.

MERIDEN.—The Quangum Cut Glass Company, of Hawley, Pa., has purchased the entire equipment from the glass plant of Hall & Callahan in this city and will ship it to Hawley.

NEW HAVEN.—The Pennsylvania Seaboard Steel Corporation will erect a one-story steel structure to cost about $25,000. The contract has been let to the Belmont Iron Works of New York.

STAMFORD.—The Stamford Rolling Mills Company has awarded to the Austin Company the contract for a new building to be used for smelting.

District of Columbia

WASHINGTON.—The Department of Agriculture has perfected a citrus fruit peeling machine and developed processes for pressing and chemically treating the removed peel whereby they believe an oil equal in quality to the imported oil may be produced at a cost to enable competition with the foreign product. The new process aims to make use of low-grade oranges heretofore wasted.

Florida

PENSACOLA.—The Pensacola Fertilizer and Oil Company, with headquarters at 21 Spruce Street, New York City, will construct an oil and fertilizer plant on a 90-acre site at Grassycove. Actual work will be started in February. The capacity of the plant will be about 100 tons of fish scrap per day and about 200 barrels of oil.

Illinois

ROCK ISLAND.—The paint factory of the Illinois Oil Company was expected to be completed during the latter part of January. The factory will be used for the mixing of oils and pigments in the process of manufacture of paint. The building when completed will cost $50,000. Mr. F. P. Welch is president of the company.

Indiana

TERRE HAUTE.—The Grasselli Chemical Company is now building a large chemical and zinc smelting plant in the north of the city, which will be completed by the first of 1918. It will represent an investment of $3,000,000 and one large building will be 250 x 300 feet. Actual work will be started about the middle of the coming spring.

TERRE HAUTE.—The Root Glass Company will rebuild the factory which was destroyed by fire in December.

Iowa

CEDAR RAPIDS.—The Holland Furnace Company has completed negotiations with the Chamber of Commerce of Cedar Rapids, Ia., and will erect a new factory in that city.

DUBUQUE.—The Adams Company will erect a large addition to its plant on Fourth Street during the coming year. The new building will house the machine shop. The company operates a foundry and manufactures hardware specialties and machinery.

Kansas

ELDORADO.—A new $300,000 refinery is planned by the Midland Refinery Company, which has recently been chartered by W. G. Skully, of Tulsa, Okla., and W. Irving Osborne, of Chicago.

Kentucky

IRVINE.—The Cumberland Torpedo Company announces the establishment of a factory at Miller's Creek for making nitroglycerin to be used in shooting oil wells.

Maine

BANGOR.—The Texas Oil Company has purchased from I. M. Pierce and W. A. Finnigan a parcel of land on the Penobscot River on which tanks and building will be erected for making Bangor the distributing and commercial center of eastern and northern Maine.

GARDINER.—Mayor Lamb has received a letter from a large Western company making inquiries regarding location for a sulphite pulp mill and asking for assistance from the city.

Maryland

BALTIMORE.—The Electric Smelting Corporation, a new company formed with a capital of $100,000, will undertake the manufacture of electric furnaces for melting copper, brass and other nonferrous metals, and for manufacturing alloys. The incorporators are Adolph Schoeneis, John F. Dirzuweit and Katharina Dirzuweit, all of Baltimore.

Michigan

MUSKEGON.—The Lakey Foundry Company will erect a large modern foundry plant which will more than double its present output. The present foundry produces about 40 tons of castings per day. It is planned to have the new structure completed by July 1.

Montana

BIGFORT.—Glacier Park Pulp & Paper Co. will erect paper mill in this vicinity, and for this purpose company has been organized at St. Paul with $100,000 capital. L. S. Gillette, pres., 827 Nicollet Ave., Minneapolis.

Nevada

ELY.—The Consolidated Copper Mines Company will build another 500-ton unit at its Giroux mill. The first 500-ton section will be placed in commission about January 15.

New Jersey

CAMDEN.—Fire caused $50,000 damage to the plant of the General Chemical Company on Cooper River. The pottery, office, laboratory and pottery storehouse were destroyed.

HARRISON.—Plans prepared for erection of addition at rear of Crucible Steel Co. plant between Sixth and Seventh Sts.; cost about $200,000.

JERSEY CITY.—The Globe Chemical Company, 168 Broadway, Jersey City, a new company capitalized at $30,000, will increase its production of benzoic acid to 100 lbs. per day. Dr. Henry W. Lorenz is superintendent of the plant.

KEARNEY.—General contract awarded by Egyptian Lacquer Mfg. Co. to Turner Construction Co., 11 Broadway, New York, for erecting one building, 2-story, 160 x 62 ft., with L 30 x 40 ft.; one 2-story, 120 x 60-ft. office building; 1-story, 60 x 60 ft., and railroad trestle.

LINDEN.—The Ammo-Phos Chemical Corporation's new plant will cost $200,000 and the Grasselli Chemical Company's factory additions will cost $85,000.

NEWARK.—The North American Copper Company, 52 Vanderbilt Avenue, New York City, will erect a large copper refining plant on the Kearny meadows between the Hackensack River and Hackensack Avenue.

NEWARK.—The plant of Seaboard By-Products Coke Company is progressing nicely and is expected to be finished soon after the arrival of better weather.

NEWARK.—The Louis Sacks Iron Foundry has added a brick pattern storage building to the group of structures at Hamburg Place. The company manufactures semi-steel.

NEWFIELD.—Work is being rushed on the new glass factory at Newfield and it is expected a large force of men will be employed as soon as the plant is finished.

RIDGEFIELD PARK.—The Bergen Paper Mill will enlarge its plant and will increase its output by 50 per cent.

New Mexico

ALBUQUERQUE.—The J. G. White Engineering Corporation has been awarded a construction and engineering contract by the Senorito Copper Corporation of Senorito, N. M., in the Nanciemento District, 90 mi. northwest of Albuquerque.

The contract covers installation of a mill and power plant, a two-mile tramway, necessary mining machinery and equipment of the company's coal mine to produce fuel for the power plant. Initial installation will be for production capacity of a quarter million pounds of copper per month. Active work has been started and construction is being rushed in order to take advantage of the high price of the metal.

The mill and plant embody some unusual features enabling the production of refined copper at the mine and eliminating the necessity of transporting the ore. This will be accomplished by the Greenawalt electrolytic method of leaching and electrodeposition.

New York

AUBURN.—The Cayuga Steel Company, Ltd., with a capital of $300,000, is considering the selection of a site for a big factory in Auburn. The company is authorized to buy, lease, erect, equip and operate furnaces, mills, shops and plants for the production of, re-working, and manufacture of iron, steel and other metals and alloys.

NEW YORK.—The By-Products Company, 10 Broadway, New York City, is contemplating the erection of addition to the boiler house at its plant on Shooter's Island, near Staten Island, to cost about $125,000. A new tankage plant will also be erected at a cost of about $150,000.

NEW YORK.—The Chemical Manufacturing Company, Inc., 46 Gold St., will begin the manufacture of dyes about February 1. The president of the company is Spencer D. Embree.

SYRACUSE.—The Semet-Solvay Company plans to make extensive experiments and to take up the manufacture of intermediates and dyes. The company has begun the manufacture of salicylic acid and plans to take up other lines.

NIAGARA FALLS.—The American Magnesium Corporation, a newly organized company, with a capital of $300,000, will establish a factory at the far north end for the manufacture of magnesium. It is also authorized to manufacture barium, calcium and other metals. The directors are E. W. Burdick, I. J. Hallenbeck and J. J. Devereux, all of New York.

MONTICELLO, N. Y.—The Mont Color & Chemical Company has been formed to produce chemicals, intermediates and dyes from coal tar. Some equipment has been ordered but further purchases will likely be made in the near future. The company would like to receive catalogs from machinery and other houses. Mr. F. P. Brenner is manager.

Ohio

BELLAIRE.—Several of the glass factories in this section are experimenting with crude oil and coke on account of the gas shortage.

CANTON.—The United Furnace Company has started operations at its new blast furnace here. Its daily output is to be 450 tons. A by-product coke oven and benzol plant is also practically finished. The new furnace will supply hot metal to the United Alloy Steel Corporation.

CINCINNATI.—The Comfort Paper Company, recently incorporated with a capital of $400,000, plans the erection of a large paper mill for the manufacture of book papers in the Millcreek Valley, not far from Cincinnati. The incorporators are George O. Comfort, of Kalamazoo, Mich.; M. J. Sullivan, of Cincinnati; William A. Stuart, of the Browne & Stuart Company; Charles B. Wing and Thomas H. Kelley.

CINCINNATI.—Plans being prepared by Ward Baldwin, consulting engineer, 809 Commercial Tribune Building, for erecting addition to Union Distilling Company's plant, Carthage; estimated at $200,000.

LORAIN.—The United States Steel Corporation is said to be back of a $200,000 land purchase here with the idea of erecting another steel plant.

Oklahoma

ALLEN.—The Crystal White Refining Company has recently increased its capacity from 300 to 1000 barrels a day.

Oregon

OREGON CITY.—The Hawley Pulp & Paper Company will shortly commence work upon its second big unit of the mill which it is erecting. The first unit has been completed and the machine is now being installed. The total cost of this unit was $1,000,000.

Pennsylvania

COATESVILLE.—The Lukens Iron & Steel Company will erect a new mill for the rolling of steel plates which will be the largest similar unit in the world. The new mill will be 17 feet wide, capable of rolling plates up to 192 inches in width. The two largest mills in the United States at present roll 152-inch plates and a 168-inch mill is the limit of the British Isles. Coatesville, with the extension of the Lukens Company and the expenditure of $10,000,000 on extension to the Worth Bros. plant, is rapidly forging to the front as a steel manufacturing center.

HARRISBURG.—Mr. L. M. Lawson, of Bridgeport, Conn., has recently been in Harrisburg in the interest of a $1,000,000 project for the growing and refining of sugar beets in this community. If possible a plant will be built with local capital.

JOHNSTOWN.—The Franklin plant of the Cambria Steel Company has broken ground for two new blast furnaces to cost $3,000,000. A car wheel plant to cost $4,000,000 will also be built. Further extensions are expected but have not yet been officially announced.

MARCUS HOOK.—Some interesting figures on the growth of Delaware County last year are presented. New buildings were put up by the Benzol Products Company, General Chemical Company, Congoleum Company, Viscose Company, Sun Oil Company, all in Marcus Hook, reaching an approximate cost of $5,000,000.

SOUTH BETHLEHEM.—The Bethlehem Steel Company has announced that it will erect an ingot foundry with a capacity of 500 tons a day. The foundry will be equipped with the very latest appliances and will cost $750,000.

Tennessee

CHATTANOOGA.—The Lookout Paint Company, whose plant was destroyed by fire, will rebuild same and within thirty days expects to have temporary building erected and a portion of the plant put in operation.

Texas

HOUSTON.—A large tract of land on the Sabine-Neches Canal, between Beaumont and Port Arthur, has been purchased by E. L. Doheny, of California, who expects to erect a $2,000,000 refining plant for refining oil.

Utah

SALT LAKE CITY.—Local capitalists interested in the West Cache Sugar Company have been selecting site in Northern Utah for a new sugar factory. The company has purchased the Knight Sugar factory at Raymond, Canada, which will be moved to Utah.

Virginia

HOPEWELL.—The Dupont Company has awarded contract to the Westinghouse Electric Company for a large electric generator for its new nitrogen plant under construction at City Point. The new generator will have a capacity of 25,000 horsepower.

Washington

PORT ANGELES.—Whalen Brothers, of Canada, are understood to have under consideration the erection of a large paper pulp mill in Port Angeles, Wash. The enterprise has been financed by Peabody, Houghteling & Co., of Chicago. Construction of the plant will begin about the first of February and will be finished in eight months. It is expected that other paper mills will be erected on Puget Sound in the near future.

SPOKANE.—The Berlin Dye Works plans the erection of an addition to its plant. Mr. Joseph Mackoff, proprietor, has left for Chicago to purchase new machinery.

TACOMA.—Owing to increased capacity at the plant of the American Smelting & Refining Company here (refineries nearly double in size), the company will erect a new stack for carrying off gases, etc. The new stack will be 550 feet high, 30 feet higher than the one at Butte, which now holds the record, and will be 25 feet in diameter at the top. The new stack will be equipped with a Cottrell precipitator for recovery of fine metallic dust. The present stack is equipped with this apparatus and from 10 to 15 tons of fume per day are recovered in this manner. In the new stack it is expected to recover 30 to 40 tons per day.

TACOMA.—The Standard Chemical Company will commence the erection of new buildings to house machinery, etc., for the manufacture of caustic soda, and flotation oils. The cost of the new plant will be between $7,000 and $8,000. The company is chiefly engaged in the manufacture of coal-tar derivatives, disinfectants, etc.

West Virginia

GRAFTON.—The Hazel-Atlas plant, which manufactures glass, is growing rapidly. The original plant is now practically complete. The plant is turning out about four cars of finished product per week. The company expects to commence the erection of a second tank on the original site in the near future. With the second tank running, and if the gas department is successful in supplying the required amount of fuel, the company looks forward to putting in another plant of exactly the same type at the east side of their property.

WHEELING.—American Bottle Company, subsidiary of the Owens Bottle Machine Company, 30 East Rand Street, South Chicago, will erect $2,000,000 plant here for manufacture of pint glass bottles.

WHEELING.—The Whitaker-Glessner Company of Wheeling will erect a large sheet mill on its Beech Bottom property. The plant will consist of eight hot mills and is expected to be ready by August.

Wisconsin

STEVENS POINT.—The Whiting-Plover Paper Company will make improvements costing $100,000 during the coming year. A warehouse costing $50,000 and two new water wheels will be the most important items.

Canada

CHATHAM, ONT.—In the Calgary field the Calgary Petroleum Products Company has installed a small experimental refining plant at its wells near Okotoks. The company is preparing plans for a larger plant. In the Tilbury gas field the Union Natural Gas Company has finished a gasser on the Chris Armstrong farm near Glenwood.

The Imperial Oil Company, which constructed several new stills at its Sarina refinery, is stated to be planning other large extensions in 1917. The Perfection Stove Company and allied concerns has recently constructed a large addition to its factory.

Manufacturers' Notes

FERROCHROMIUM NOW MADE ON PACIFIC COAST.—The first fifty-ton carload of ferrochrome produced on the Pacific Coast was shipped East on Jan. 15 by the Noble Electric Steel Company. The Noble Company is doing a large business at present.

PAPER EXPORTS DOUBLED.—Exports of paper and paper manufactures this year will reach $40,000,000, doubling those of any previous year, according to figures assembled by the Bureau of Foreign and Domestic Commerce.

News print paper exports this year have reached a total value of $3,430,000 against $2,260,000 last year, about half of it going to Latin-America. It would seem that there are other reasons besides the shortage and high cost of raw materials for our high paper prices.

AMERICAN FIRM GETS BIG ARGENTINE CONTRACT.—The second largest contract ever awarded by the Obras Sanitarias de la Naciôn of Buenos Aires, Argentina, was obtained recently by an American firm. The United States Cast Iron Pipe & Foundry Company will supply 60,000 tons of pipe, amounting to about $3,500,000. The American commercial attaché at London, England, was of assistance in bringing this contract to the United States. A report on the subject has been received from Secretary L. B. Clark, in charge of office of commercial attaché, Buenos Aires.

BRITISH EXPORT PROHIBITIONS.—By an Order in Council dated December 12, according to the "Chemical Trade Journal & Chemical Engineer," manganese, peroxide of, and mixtures and preparations thereof; thorium and its alloys; and zirconium, and its compounds and alloys, are added to the list of goods the exportation of which from the United Kingdom is prohibited to all destinations. Lead (except pig lead), alloys of lead, solder containing lead, and manufactures of lead or its alloys, not otherwise prohibited; oil varnishes; zirconium minerals; and fish bones are prohibited from exportation to all destinations abroad other than British Possessions and Protectorates. Formates, not otherwise prohibited; iridium, osmium, palladium, rhodium, and ruthenium compounds; white lead; oxalates, not otherwise prohibited; soda lime; sulphites and thiosulphates, metallic, not otherwise prohibited; animal hoofs and other glue stock; glue, osseine and concentrated glue, size, fish glue, isinglass, finings and other kinds of gelatine; iridium, osmium, palladium, rhodium, ruthenium, and alloys of these metals are prohibited from exportation to all foreign countries in Europe and on the Mediterranean and Black Seas, other than France, Russia (except through Baltic ports), Italy, Spain, and Portugal.

The following headings scheduled in previous Orders are deleted: Manganese peroxide, prohibited from exportation to all destinations; and lead, pipe, scrap, or sheet, and solder containing lead, prohibited to all destinations abroad other than British Possessions and Protectorates.

LARGE ORDER FOR CHLORBENZOL.—The Federal Dyestuff & Chemical Company, Kingsport, Tenn., is reported to have received an order for 3,000,000 pounds of chlorbenzol, and will be executed by the company's new plant at Kingsport.

The goods are for export, and it is expected that the order can be executed within the next six months, with the largely increased and rapidly increasing capacity of the plant.

Chlorbenzol is an "Intermediate" used in the manufacture of dyes, and the Kingsport plant is now equipped to turn it out in large quantities. The demand for this chemical is heavy, and the price is far above normal.

EXPORTS FROM GERMANY TO UNITED STATES FOR 1916.—The total value of the exports invoiced at the American consulates in Germany for the United States during 1916 was $8,349,902, as against $39,967,183 for 1915. Exports to the Philippines were valued at $21,428 against $140,871. No exports were declared during the year for Hawaii or Porto Rico, while in 1915 the shipments were valued at $89,159 and $16,841, respectively. Returned American goods were valued at $2,400, against $178,546 for 1915.

CONDITIONS IN SWISS DYESTUFF INDUSTRY.—The Swiss dyestuff industry has had to cope, according to Commerce Reports with great difficulties in connection with labor and materials. There are no coke ovens in Switzerland, and the coal-tar products procurable have only been those which could be spared by belligerent countries, chiefly England. There is only one sulphuric-acid plant, but recently there has been government encouragement for the scheme for the erection of a common acid works for the dyestuff factories, nitrites, nitric acid, caustic soda, and chlorine are plentiful.

The Swiss dyestuff factories have had to supply the requirements of the home consumers, who formerly dealt almost entirely with Germany, and who are now busy with foreign orders; nevertheless a

considerable quantity has been exported under government supervision in return for raw materials allowed to come in. The price of aniline oil has risen to ten times the normal.

The Swiss silk-dyeing industry is suffering through scarcity of vegetable dyestuffs, particularly logwood. Stocks are nearly exhausted.

ADDITIONS TO BRITISH CONTRABAND LIST.—A proclamation of December 29, 1916, announces the following as additional absolute contraband:

Oxalic acid and oxalates, formic acid and formates, phenates, metallic sulphites and thiosulphates, soda, lime and bleaching powder, platinum, osmium, ruthenium, rhodium, palladium, iridium, and alloys and compounds of these metals, strontium salts and compounds thereof, barium sulphate (barytes), bone black. Schedule I, proclamation of October 14, 1915, is amended as follows: For item 8, "ethyl alcohol, methyl alcohol," substitute "alcohols, including fusel oil and wood spirit and their derivatives and preparations"; for item 35, "aluminum, alumina, and salts of aluminum," substitute "aluminum and its alloys, alumina, and salts of aluminum"; for item 41, "wolframite, scheelite," substitute "tungsten ores"; schedule II, for item 5, "fuel other than mineral oils," substitute "fuel, including charcoal, other than mineral oils."

DUST COLLECTING COMPANIES REORGANIZING.—The Clark Dust Collecting Company, Chicago, Ill., announces that it has severed its connections with the Simon, Buhler & Baumann Co., Inc., New York, as Western representatives, and that they have consolidated with the American Dust Collecting Company to build a full line of dust collecting apparatus, including the American suction filter.

RENNERFELT FURNACES IN THE UNITED STATES.—The following Rennerfelt furnaces are in operation or building in the iron and steel industry in the United States:

Crucible Steel Company of America, Crescent Works, Pittsburgh, Pa. Capacity, 750 lbs., 100 kw. tool steel.

Charleston Steel Company, Charleston, W. Va., 6-ton, 1200 kw. special steel ingots. Two furnaces.

American Foundry & Machine Company, Salt Lake City, Utah, 3-ton, 625 kw. steel castings.

Skagit Steel & Iron Works, Sedro-Woolley, Wash., 1-ton, 200 kw. steel castings.

Parsons Company, Newton, Iowa, 1-ton, 200 kw. steel castings.

The Samson Iron Works, Stockton, Cal., 1-ton, 300 kw. steel castings.

Ducas & Company, New York City, 3-ton, 750 kw. steel ingots.

J. Leslie Rodgers, 1-ton, 200 kw. tool steel, Philadelphia, Pa.

Maynard Steel Castings Co., Milwaukee, Wis., 1-ton, 300 kw. steel castings.

New company in Minnesota, not at liberty yet to mention name, 3-ton, 600 kw. steel castings.

Pacific Foundry Company, San Francisco, Cal., 750-lb., 100 kw. special iron castings.

New company, but not at liberty to mention name, 1-ton, 300 kw. steel castings.

Besides this there are two Rennerfelt furnaces of 800 lbs. each in the copper and brass industry, and one of this size for refining ferro-tungsten, another one for melting special aluminum alloys, besides ten special furnaces for making low carbon ferrotungsten.

SULPHURIC ACID IN 1916.—The production of sulphuric acid in the United States in 1916 was much greater than in 1915. The production estimated by the Geological Survey of sulphuric acid of strengths of 50°, 60°, and 66° in 1916, expressed in terms of 50° acid, is 4,475,000 tons, an estimated increase over the production in 1915 of 600,000 tons, or more than 15 per cent. The increase was distributed about equally between acids of strengths of 50° to 60°, as there was a small decrease in the production of acid of strength of 66°.

The most notable feature in the sulphuric acid industry was the enormous increase in the production of acids of strengths greater than 66°. The estimate shows a production of these stronger acids of over a million tons as against a production of less than 200,000 tons in 1915. It is not feasible to express the amount of these higher acids in terms of 50° acid; therefore the total given for them is in addition to the total given for acids of strengths of 66° or less.

The estimated output of acids of strengths of 60° and 66° includes by-product acid produced at copper and zinc smelters. The output of acid so produced in 1916, expressed as 60° acid, amounted to nearly 950,000 tons, or practically the same as in 1915. However, over 110,000 tons of acid of higher strengths was produced at these smelters, a quantity nearly double that produced in 1915.

The market conditions throughout the country are reported to have been on the whole better than in 1915, and the value of the product will probably be somewhat higher than it was even during that year of high prices.

MANGANESE IN 1916.—Preliminary estimates by D. F. Hewett, of the United States Geological Survey, Department of the Interior, show that the production of manganese ore in 1916 was about 27,000 tons, the greatest since 1888 and nearly three times that in 1915, which was 9,709 tons. The estimate does not include manganiferous iron ores that contain less than 10 per cent of manganese, but it is very probable that the production of ores of this class also was much greater than in 1915. This output has come largely from seven states, and the order in production will probably prove to be as follows: California, Arkansas, Arizona, Georgia, Virginia, Utah, Colorado. This order is interesting, because this is the first year in which a western State remote from the steel-producing centers has contributed the largest amount of manganese ore. The activity among manganese mines in California is due largely to the market for ores provided by the Noble Electric Steel Company at Heroult. It is not yet possible to state the production of high-grade ores adapted for use in dry batteries, but reports indicate that it will exceed 2,500 tons and therefore be five times that in 1915. Ores of this class are now produced in Arizona, California, Utah, Colorado, and Virginia, but the amount produced is still scarcely one-tenth the normal demand.

The prices paid for manganese ore adapted to the manufacture of ferromanganese rose from a maximum of $22.50 for 50 per cent ore in 1915 to $32.50 in March, 1916. Except for minor fluctuations, which depended on temporary variations in demand, prices were nearly constant until the last month of the year, when sales at prices as high as $39 for 50 per cent Indian ore were reported. There were rumors that a contract for the delivery of 200,000 tons of Brazilian ore during 1917 was placed at $23 per ton f. o. b. Brazilian port, from which the freight rate to Baltimore is $12 a ton. Ore adapted to the manufacture of dry batteries (containing 80 per cent of manganese dioxide and less than 1 per cent of iron) continues to sell for about $85 a ton.

Imports of Manganese ore for the first ten months of 1916 amounted to 495,299 tons, of which 401,177 tons came from Brazil. For the same period of 1915 Brazil supplied 181,258 tons out of the total of 192,286 tons. There is a prospect, therefore, that the imports for the entire year will prove to have been almost double those of 1915—320,778 tons. Considering the small part of the demand that was supplied by Brazil during the eight years prior to 1914, it is reassuring to know that the deposits of that country can be made to yield such enormous quantities of ore. Imports from India, Cuba, Panama, and Japan were also greater than in 1915.

Imports of ferromanganese for the first eleven months of 1916 were 73,435 tons, which is nearly 50 per cent more than for the corresponding period in 1915, though bearing a smaller ratio to the domestic production. Prices reached the highest figures ever recorded in the United States in April, 1916, when, it is reported, $400 a ton was paid for a small lot for immediate delivery. For the remainder of the year the price declined steadily to $160 a ton in October, then rose to $175 again in December. The price of spiegeleisen carrying 20 per cent of manganese ranged from a maximum of $52 in July to $40 in December.

An important consequence of the prevailing high prices of manganese alloys is the attempt on the part of steel makers to use substitutes. The extent to which substitutes for manganese in steel may be used has not been determined, but experiments by several steel works show that an alloy of iron, carbon, and titanium may be satisfactorily used to replace a part of the ferromanganese commonly added.

Although a number of mines in Virginia, Georgia, and Arkansas were reopened during 1916, the greatest activity is reported among mines in California, Arizona, Utah, New Mexico, and other western States. This is due in part to the operation of electric reduction plants in California and Washington, but more largely to the low percentage of iron in some of the western ores. Few eastern mines that operate residual deposits can produce at a profit in large quantities ore that contains less than 1 per cent of iron, and therefore most of the eastern mines ship their product to eastern furnaces to be reduced to ferromanganese. The inaccessibility of most western deposits makes it unprofitable to ship ore to eastern makers of ferromanganese, even at the high prices they are now offering for manganese ore. On the other hand, many western deposits are known and more have been discovered during recent years, which are capable of producing manganese ore with less than 1 per cent of iron. At prevailing prices for such ores, they may be profitably shipped as far east as New York. There is a prospect at present that several western mines may be able to ship high-grade ores to eastern markets even when prices recede to the level of years prior to 1914.

ITALIAN FIRM WANTS CATALOGS.—The firm of Stauble & Salvini, 76 Foro Bonaparte, Milano, Italy, is desirous of receiving catalogs, prices and conditions of sale from American manufacturers of electrical apparatus and other industrial material.

BONUS FOR CUTLER-HAMMER EMPLOYEES.—The shop employees of the Cutler-Hammer Manufacturing Company, of Milwaukee, all received a Christmas present in cash the 23rd of December, and before New Year's Day a notice was posted which advised everyone of a bonus of 10 per cent of the yearly wages or salary. This bonus went to all of the 2,400 employees of this company.

MOULTON ENGINEERING COMPANY OPENS NEW YORK OFFICE.—The Moulton Engineering Corporation, of Portland, Me., announces the opening of a New York office in the Woolworth Building. Mr. Horace W. Flashman, who for a number of years has been associated with the Westinghouse Electric & Manufacturing Company, will be in charge of the office. The company is prepared to render service in general, civil, mechanical, chemical, and power engineering, and in the development of special process. The company is also associated with the Electron Chemical Company, manufacturers of the Allen-Moore electrolytic cell.

Manufacturers' Catalogs

ESTERLINE COMPANY, Indianapolis, Ind. Esterline graphic efficiency instruments model E B, catalog No. 369. Clocks, ammeters, voltmeters, wattmeters, speed recorders, etc.

KIESELGUHR COMPANY OF AMERICA, 11 Broadway, New York City, Sil-O-Cel products for heat insulation, in boiler settings, hot blast stoves, flues, furnaces, kilns, ovens, etc.

MESTA MACHINE COMPANY, Pittsburgh, Pa. Mesta improved pickling machines. Patented. For pickling sheet and tin plate and a large number of miscellaneous metal products.

SPRAY ENGINEERING COMPANY, Boston, Mass., Spraco equipment for washing and cooling the ventilating air for steam-turbine-driven generators.

Other New Publications

PEAT IN 1915. By James S. Turp. Geological Survey Report.

STONE IN 1915. By G. F. Loughlin. Geological Survey Report.

THE SUICIDE OF THE HORSESHOE FALL. By John Lyell Harper.

A NUMERICAL CLASSIFICATION OF PHOTOGRAPHY. Issued by the Research Laboratory, Eastman Kodak Company, Rochester, N. Y.

ORGANIZATION, PLAN AND SCOPE OF THE NATURAL RESOURCES SURVEY OF CANADA. Bulletin No. 1, issued by the Natural Resources Survey. Arthur D. Little, Ltd., Montreal, Directors.

A USEFUL MANUAL FOR OIL MEN. Compiled by Thomas P. Melvin, issued by the Phoenix Refining Company, Tulsa, Okla.

THE ANALYTICAL DISTILLATION OF PETROLEUM. By W. F. Rittman and E. W. Dean, issued by the Department of the Interior, Bureau of Mines, Washington, D. C.

A GENERAL SUMMARY OF THE MINERAL PRODUCTION OF CANADA DURING THE CALENDAR YEAR 1915. By John McLeish, issued by the Canada Department of Mines, Mines Branch, Ottawa, Can.

GEOGRAPHY OF THE UPPER ILLINOIS VALLEY AND HISTORY OF DEVELOPMENT. By Carl Ortwin Sauer. Issued by the Illinois State Geological Survey, University of Illinois, Urbana, Ill.

THE PRINCIPLES AND PRACTICE OF SAMPLING METALLIC METALLURGICAL MATERIALS. By Edward Keller. Bureau of Mines Bulletin 122. The bulletin devotes especial attention to the sampling of copper bullion.